THE Petroleum Engineer

JUNE 1934

VOLUME V NUMBER X

THE ENGINEERING MAGAZINE OF THE OIL AND GAS INDUSTRY

This Issue Contains

DRILLING AND PRODUCTION

	Page
Recent Developments in the Use of Bottom-Hole Chokes in Oil and Gas Wells — By K. C. Sclater	20
Electric Power in Drilling and Production of Petroleum — By W. C. Lane	38
Large Volume Oil-Well Pumping with Electrical Power — By W. H. Stueve	44
Electric Power in the East Texas Oil Field — By J. E. Elliott	49
Largest Direct-Current Rotary Drilling Rig Is In Operation in Oklahoma — By W. C. Lane and D. M. McCargar	57
Elements of Applied Petroleum Production — By K. C. Sclater	70

REFINING AND NATURAL GASOLINE MANUFACTURE

Refining Western Kansas Crude Oil — By Carl W. Berger	25
Notes on Absorber Design — By F. L. Kallam	29
Low-Capacity, High-Head Centrifugal Pumps for Refinery Uses — By W. R. Layne	35
Uses of Electricity in the Refinery — By H. L. Van Bradt	62
Elements of Applied Petroleum Refining — By W. L. Nelson	65

OIL AND GAS TRANSPORTATION

Blending Facilities at Gasoline Trunk Line Station — By Frank H. Love	23
Modern Stations on Western Gas Line — By J. F. Weadock	27
Historical Resume of Electric Motors on Oil Pipe Lines — By G. R. Prout	52

REGULAR DEPARTMENTS

The Course of Oil	11
Highlights in Oildom	12
Latest Activities in the Oil Fields	14 and 15
Progress of Major Pipe Line Work	16
The Month's Activities in Refining	18
Laugh with Barney	75
Strange But True	76
Running Tour with Men in the Industry	78
New Petroleum Equipment	80 and 81

Meetings

American Society for Testing Materials, Annual Meeting—June 25, 26, 27, 28 and 29, Atlantic City, New Jersey.

•

Drake Well Memorial Celebration—August 24, 25, 26 and 27, Titusville, Pennsylvania.

•

American Chemical Society—September 10, 11, 12, 13 and 14, Cleveland, Ohio.

•

American Institute of Mining and Metallurgical Engineers, Petroleum Division, Fall Meeting—October 12 and 13, Mayo Hotel, Tulsa, Oklahoma.

•

American Gas Association, Convention and Exhibition—October 29, Atlantic City, New Jersey.

•

American Petroleum Institute, Fifteenth Annual Meeting—November 12, 13, 14 and 15, Dallas, Texas.

•

National Exposition of Power and Mechanical Engineering—December 3, 4, 5, 6, 7 and 8, Grand Central Palace, New York City.

•

Society of Automotive Engineers, Annual Dinner—January 7, New York City.

THE PETROLEUM ENGINEER PUBLISHING COMPANY

Tower Petroleum Building :: Dallas, Texas

C. Morris - - - - - *President-General Manager*
J. L. Dwyer - - - - - - - - *Vice-President*
T. J. Crowley - - - - - - - *Vice-President*
W. T. Bryan - - - - - - - *Secretary-Treasurer*
W. L. Love - - - - - - - *Advertising Manager*
C. R. Barrett - - - - - - *Circulation Manager*
K. C. Sclater - - - - - - - - - *Editor*
Frank H. Love - - - - - - *Associate Editor*

COPYRIGHT—Each issue of The Petroleum Engineer is copyrighted. Any republication of the matter appearing in the magazine, either wholly or in part, is not permitted except by special authorization. SUBSCRIPTION PRICE *—Single copies 15 cents. Domestic and foreign, $1.00 per year, three years $2.00, with the exception of Canada, where the price is $1.65 per year, three years $3.95.*

MEMBER A. B. C.

NRA MEMBER U.S. WE DO OUR PART

MEMBER A. B. P.

The Service Record of This Wire Rope Continues to Make and Hold Friends

Just any kind of wire rope no longer satisfies the producer or contractor who expects to operate on an economical basis, for it has been proved that the life of the wire line used has a lot to do with final cost.

In the making of "HERCULES" (Red-Strand) Wire Rope, the first consideration is to produce a product that will be able to stand up under the wear and tear of hard work—one that can give a lot of service in return for each dollar of its cost, as final results rather than first cost are what determine real economy.

To accomplish this, all "HERCULES" (Red-Strand) Wire Rope is made of acid open-hearth steel wire, and every wire used is first rigidly tested by us to make sure it meets our exacting requirements; moreover, we design and build our own wire rope-making machines, and have our own exclusive manufacturing methods—and back of all is our 77 years of manufacturing experience.

Made Only by

A. Leschen & Sons Rope Co.

Established 1857

5909 Kennerly Avenue, St. Louis, Mo.

New York - - - - - - - - 87 to 90 West Street
Chicago - - - - - - - 810 W. Washington Blvd.
Denver - - - - - - - - - - 1554 Wazee Street
San Francisco - - - - - - - 520 Fourth Street

Domestic Distributors

CASEY & NEWTON
901 Century Building
Pittsburgh, Pa.

HILLMAN-KELLEY, Incorporated
2441 Hunter Street
Los Angeles, Calif.

HINDERLITER TOOL COMPANY
Tulsa, Okla.

NORVELL-WILDER SUPPLY COMPANY
Beaumont, Texas

OSBORN MACHINERY COMPANY, Inc.
Clarksburg, W. Va.

PARKERSBURG SUPPLY COMPANY
Parkersburg, W. Va.

UNION PIPE AND SUPPLY COMPANY, Inc.
Owensboro, Kentucky

UNITED PIPE AND SUPPLY CORPORATION
Charleston, W. Va.

Export Distributor

CONTINENTAL EMSCO CO., Inc.
19 Rector Street, New York, N. Y.
Branches
Buenos Aires London Ploesti

The Course of Oil

By K. C. SCLATER

Another Increase in Drilling Depth

Completion of a prospect well to a total depth of 11,377 feet has just been successfully carried out in the South Belridge field, California. This is almost 500 feet deeper than the deepest hole yet drilled for oil. An accomplishment of this kind has more significance than the mere matter of depth.

Every increase in drilling depth has a bearing on the estimation of oil reserves. The future oil reserves brought within the reach of the drill are augmented.

Lifting costs of deep wells, particularly in the later life of the field, are such as to require the application of the most modern and highly approved engineering methods. Failure to recognize this often results in shortening the economic life of deep wells to the point that they have to be abandoned long before they have produced a fair return on the investment. Thus do increases in drilling depth emphasize the need for more engineering in the development of new fields. Most of the important discoveries in the future will probably be made at a depth of 10,000 feet or more.

It has come to light that in the drilling of this well emphasis was placed on the care employed in all details of drilling and more especially with regard to the stresses to which the materials used were subjected. When it is considered that the total weight of the casing and tubing is close to 534 tons the necessity for the care exercised becomes obvious. Where such quantities of material are involved modern engineering practices are essential; rule-of-thumb methods have no place. The slightest mistake may prove to be very costly. Completion of this well is a pioneer undertaking; as is that of any well that goes so far beyond existing depths. It is a tribute to the skill of those connected in any capacity with the drilling operations and to the methods and the skillful use made of the equipment employed.

Encouraging Signs in Industry

Goverment statistics based on reports that include 46 identical manufacturers show an encouraging increase in new orders booked for fabricated steel plate for use in the oil industry. Refinery materials and equipment show 6650 tons for the first four months of 1934, as against 1443 tons and 1770 tons for the same period of 1933 and 1932, respectively. Steel requirements for new tank cars was 810 tons for the first four months of 1934, as against 146 tons and 181 tons for the same period of 1933 and 1932, respectively. Steel requirements for oil storage tanks have not shown much change. For the first four months of 1934 they were 11,430 tons, as against 14,318 tons and 11,459 tons for the same period of 1933 and 1932, respectively.

Were segregated figures available showing the new steel requirements for use in the producing branch of the industry they would compare favorably with the tonnage for refinery materials and equipment, for many oil operators in all parts of the country, stripper well owners in particular, have launched a program of renovation and repairs on well and lease equipment.

Ownership of Oil in Place Underground

An important point of law has come up in California over charges of underground trespassing involving the theft of oil. In order to reach productive oil-bearing sands an operator has purposely drilled a crooked hole. In doing so, he has drilled beyond the vertical boundaries of his own tract and penetrated the oil sands underlying the property of an adjacent operator. Before the question of trespassing by means of drilling a crooked hole can be settled, it appears that the matter of ownership of the oil in place underground must first be decided. It is contended by the defendant in this case that oil in place underground is not personal property and does not become such until reduced to possession at the surface.

There can be no theft of real property according to law if this is the view in regard to oil held by the courts, so the question of whether oil underground is real or personal property must first be decided by court action before the question of trespassing can be considered.

This question of ownership of oil in place underground is of fundamental importance, more so today than ever before. Those days have passed when it was difficult or virtually impossible to offer any tangible evidence regarding underground conditions. It is now possible to obtain factual evidence showing the underground course of a drilled well, and thus to offer definite proof regarding the exact position of the bottom of the hole and the immediate area from which the oil produced by the well is drawn. To assume that oil in place underground is real property rather than personal property—interpreting these two terms as usually defined by the law—is in effect an enunciation of the "law of capture."

The time has arrived when the ownership of oil underground must be more clearly defined by the courts. On such a definition of ownership rests what might be considered the very fundamentals of good oil production practice and vitally affects the exploitation of competitive pools of diversified ownership. Under field operating conditions the migration of oil and gas from one property to another while the field is being produced must sooner or later have to be considered.

Should oil in place underground be regarded by law as personal property operators in oil pools of diversified ownership may be obliged to produce their properties in such manner that migration of oil across property lines would be prevented. Looked at from this angle, the decision concerning the ownership of oil in place underground will have an important bearing on production practice in many fields of the United States.

« « « HIGHLIGHTS IN OILDOM » » »

Injunction Against Oil Code Dissolved

Upholding the right of the Federal Government to apply national recovery administration regulations to oil production in Texas, the United States Fifth Circuit Court of Appeals at New Orleans, Louisiana, has ruled out an injunction granted to the Amazon Petroleum Corporation and other oil companies in the Eastern Texas District Court.

The injunction restrained Federal agents from enforcing provisions of the NRA code upon the grounds that they violated the Constitution. Oil companies attacking the code charged Congress with attempting to delegate legislative powers to the President and to vest in him powers of a supreme dictator, "contrary to our republican form of government." They also alleged their rights were violated by the NRA provision requiring the filing of oil production reports.

In ruling that there had been no unconstitutional delegation of legislative power by Congress, the court said: "While Congress can not abdicate legislative power it may make a large delegation of it, always retaining the right of control and of reassumption."

In answer to the assertion of the oil companies that they were not engaged in interstate commerce but only in intrastate activity, the appellate court stated: "The fact that the producers themselves do not engage in interstate commerce does not render it less necessary that they furnish information. The inspection of books is only a check on the truthfulness of the reports."

Similar suits brought by the Panama Refining Company and other oil concerns were ordered dismissed.

●

Oil Control Bill Still Pending

With a mixed sentiment existing upon the desirability of a law placing control of the petroleum industry in the hands of the Federal Government, and consequently no concerted effort on the part of oil interests to effect its passage, it now appears that the Thomas-Disney bill has a very slight chance of becoming enacted at this session of Congress. Changed somewhat from its original form, the measure still is meeting with strong opposition, as well as having its advocates.

As a concession to those opposed to its passage on the grounds that they fear placing control of the oil industry in the hands of Federal agencies for an indefinite period, an amendment has been offered limiting the life of the law to two years. Secretary Ickes has gone on record as opposed to such a limitation, however.

Opponents of the bill also maintain that, since the United States Fifth Circuit Court of Appeals at New Orleans ruled recently that Federal agents were exercising constitutional authority in applying national recovery administration regulations to oil production in Texas, there is now no need for the proposed legislation.

In answer to this contention Secretary Ickes has pointed out that, while helpful, the decision merely authorizes the Federal Government to assist state regulatory bodies in enforcing production orders. Since there are only three states having regulatory bodies (Texas, Oklahoma and Kansas) it does not decide the Federal Government's right to prosecute violations of producing orders under the code in any of the other 15 oil-producing states, he says. Furthermore, it does not sustain the right of the Federal Government under the code to control the amount of production of the states having state regulatory agencies, Mr. Ickes maintains.

●

Court Reaffirms Stand in Wilcox Case

The Oklahoma Supreme Court has reaffirmed its stand that all proration orders of the State Corporation Commission made prior to the passage of the present proration bill April 10, 1933, were invalid. A petition by the commission for a rehearing in the H. F. Wilcox Oil and Gas Company case has been denied.

The original opinion cancelled penalties against operators who over-produced approximately 10,000,000 bbl. of oil in the Oklahoma City field.

●

Fix Cost of Drilling in Texas

The Texas committee on drilling practices functioning under provisions of the oil code established cost figures at a meeting held in Houston recently. The cost for drilling in East Texas is placed at $1.51 per foot for a straight footage contract, the contractor to furnish machinery and all drilling labor, take two free cores, and supply labor for one day for connecting up and completing a well, with any other material or service furnished by the contractor to be paid for at a price above the footage price and commensurate with the value of such service or material.

Cost in the Greta area is set at $2.73 per foot on a straight footage contract, with drilling mud and blowout preventer to be furnished by the contractor in addition to requirements for East Texas.

In the Government Wells field of Duval County the cost is placed at $1.48 per foot on a straight footage contract with virtually the same requirements as in the East Texas field.

These figures became effective May 23 and the drilling of a well for less constitutes a violation subject to the maximum penalties recorded in the National Recovery Act.

●

Oklahoma City Potentials Decline

Recent tests made on 456 wells in the Wilcox zone of the Oklahoma City field reveal a 41 per cent decline in potentials compared with last October. The announcement is made by the proration department of the state. The wells showed a combined new potential of 1,723,408 bbl. compared with 2,925,792 bbl. in October. Open flow tests were taken on 234 wells and these showed an average decline of only 12.8 per cent. On the remaining 222 wells production tests were made and the average decline was 62.7 per cent. Twenty-one new wells in the zone show a combined new daily potential of 92,797 barrels.

●

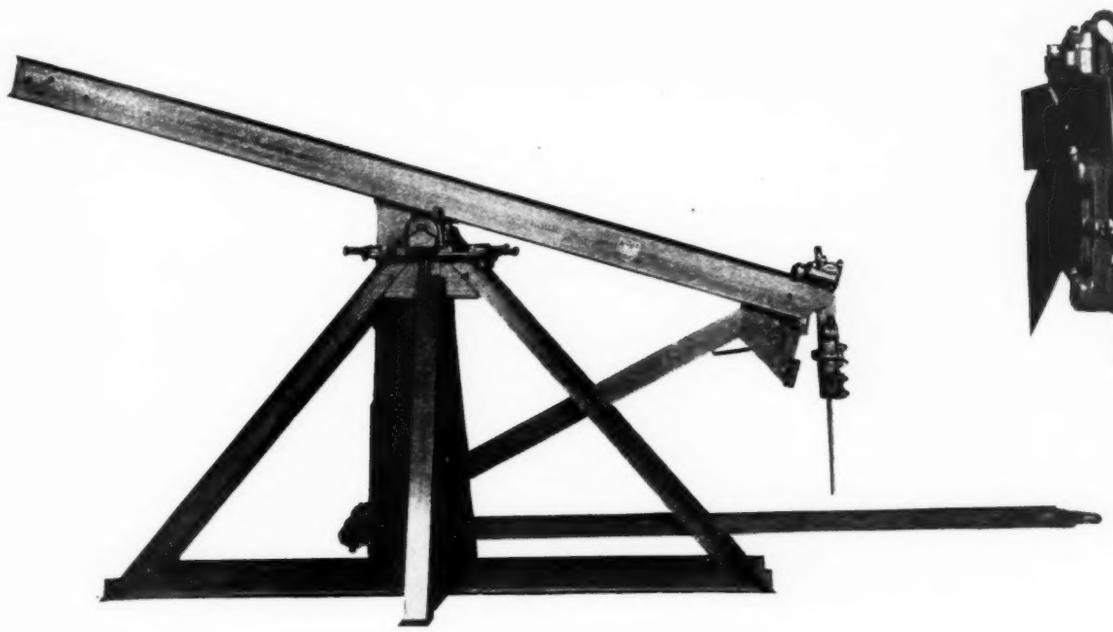
Dallas New Headquarters for Code Enforcement

In the future Dallas will be headquarters for the Bureau of Investigation directing operations of Federal officers enforcing the oil code in Texas, it has been announced by Secretary Ickes, national oil administrator. The Tyler, Texas, force will be moved to Dallas.

Simultaneously with Secretary Ickes' announcement, Louis R. Glavis, chief of the Division of Investigation for the oil code, stated that the Federal Government would launch immediately a vigorous campaign against producers of "hot oil" and other East Texas violators of the code.

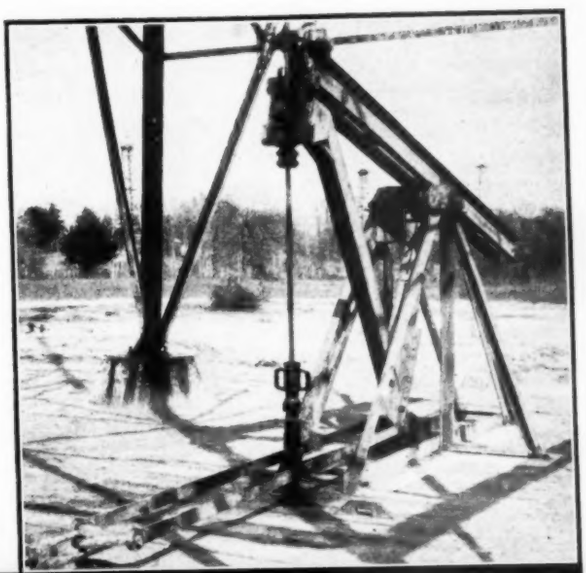
NATIONAL PUMPING JACKS

TYPES D-80, D-100 AND D-130-S



National Type D Jacks are designed and constructed for long stroke pumping of deep wells. All steel, arc welded construction which gives excess strength and extreme rigidity; extra large, enclosed bearings; adjustable position; variable stroke; approximate straight line motion; sand and water-proof lubrication—all are combined to provide economical installation, efficient operation and long, dependable service.

Bulletin No. 534 free on request.



THE NATIONAL SUPPLY COMPANIES

LATEST ACTIVITIES IN THE OIL FIELDS

KANSAS is again in the limelight with the bringing in of several discovery wells within recent weeks. The Tom Palmer No. 1 Nordling in McPherson County, is producing 27-gravity oil from the Viola lime at 3190-3197 ft. and is estimated as a 300-bbl. well. It is approximately one mile north of the old McPherson gas field. No. 1 Graber of the Continental Oil Company, also in McPherson County, found production in the Hunton lime at 3274-3292 ft., the oil testing 42 gravity. Phillips Petroleum Company's No. 1 Dopita in Rooks County swabbed 112 bbl. of oil in six hours from the Oswald lime at a total depth of 3317 feet. Rooks County is two counties from the Nebraska line and is well past the center of the state of Kansas to the west. This well may result in a new play in that part of the state. E. B. Shawver's No. 1 Brookings, in Sedgwick County, made 225 bbl. of oil daily from chat formation at a depth of 3069-3099 feet. This well extends the old Robbins pool approximately one-half mile to the north. No. 1 Lansing in Rice County, joint well of the Continental, Shell and Empire companies, encountered the Arbuckle limestone at 3132 ft., and at 3172 ft. the hole filled up 2300 ft. with oil.

●

Southwestern Cherokee County is the latest scene of oil excitement in the State of Texas. The New Birmingham Development Company on June 3 brought in a wildcat well, No. 1 T. J. Woods, six miles southwest of Rusk, Texas. The well produced 39.5-gravity oil from the lower Woodbine at a total depth of 5120 ft., making approximately 25 bbl. per hour through a ¼-in. choke on the initial test. Casing was set and cemented at 5112 feet.

●

Added importance has been given the Louisiana Gulf Coast area with the completion of a deep wildcat well in the Roanoke prospect of Jefferson Davis Parish. The Shell Petroleum Corporation's Kratzer No. 1 was brought in recently making an initial flow of 47 bbl. of 37 gravity oil per hour through 9/32-in. choke from a depth of 8682 feet. Later production increased slightly to 50 bbl. per hour.

Two shallow oil pools have been discovered in West Texas. Petroleum Oil Interests, Inc., and Watts Brothers brought in a well seven miles north of Brownwood in Brown County that flowed two bbl. hourly from 1325-1327 feet. In Coleman County, the Eppenauer Drilling Company has a well with an estimated potential of 100 bbl. producing from the Fry sand at 1872-1876 feet. The location is three miles northwest of Santa Anna.

●

Two new Wilcox sand pools appear to have been opened in the Greater Seminole field of Oklahoma. No. 1 Meyers of the Winona Oil Company and Jarvis & Holm, Inc., eight miles south of Wewoka and seven miles north of Sasakwa, drilled to a total depth of 4216 ft., produced 500 bbl. of oil the first hour. The other strike was the Fleetborn Oil Company's No. 1 Bowlegs, several miles east of Wewoka, an old Hunton lime well deepened. The well was completed at 4214 ft. and swabbed and flowed 165 bbl. in three hours.

●

An extension was given the Iowa Dome pool in Jefferson Davis Parish, Louisiana, when the Barnsdall Oil Companys' No. 1 Raffal found the Iowa sand at 6976 to 6987 feet. The well flowed 1000 bbl. of oil in 24 hours through a ½-in. choke.

●

The Cut Bank field of Montana has been given a three-mile extension that may result in the union of the field proper with the south area. The extension well was the Montana Power Gas Company's No. 1 Neill, which found production at a total depth of 3010 ft. and swabbed 150 bbl. of oil the first 12 hours.

●

The General Petroleum Corporation's No. 1 Berry at Belridge, California, in Kern County, has reached a depth well past 11,000 ft., making it the world's deepest test. At 11,370 ft. liner was set preparatory to making a production test. The formation is shale with streaks of oil sand showing.

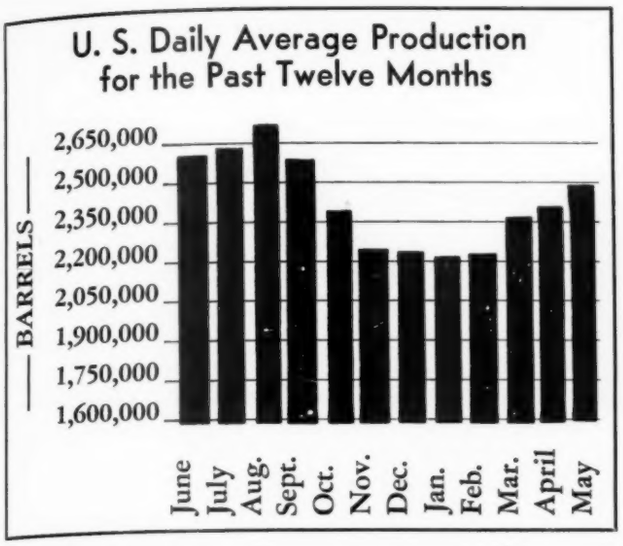
AVERAGE CRUDE OIL PRICES

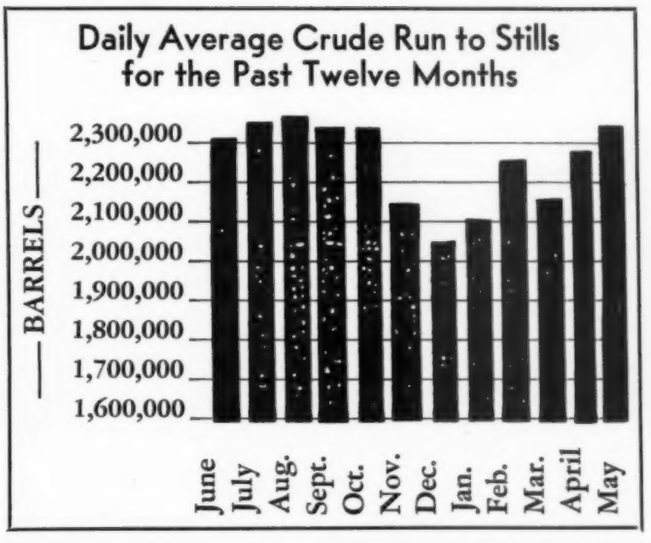
California		Louisiana	
Playa Del Rey	$ .90	North Louisiana	$ .95
Coalinga	.81	Gulf Coast	1.04
Signal Hill	1.12	Illinois	1.12
Montana	1.35	Kentucky	1.17
Wyoming	1.00	Indiana	1.12
Colorado	1.00	Ohio	
New Mexico	.75	Lima	1.30
Texas		Michigan	1.02
North Central	.95	Pennsylvania	
Panhandle	.83	Bradford	2.55
West Texas	.70-.75	Southwest	2.22
Gulf Coast	1.04	Eureka	2.17
Darst Creek	.87	Buckeye	2.07
East Texas	1.00		
Kansas	1.00	West Virginia	2.07
Oklahoma	1.00	Canada	2.10
Arkansas	.70		

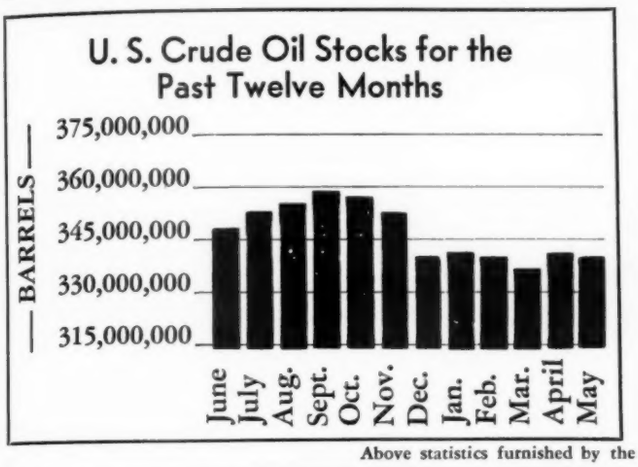
DAILY AVERAGE CRUDE OIL PRODUCTION

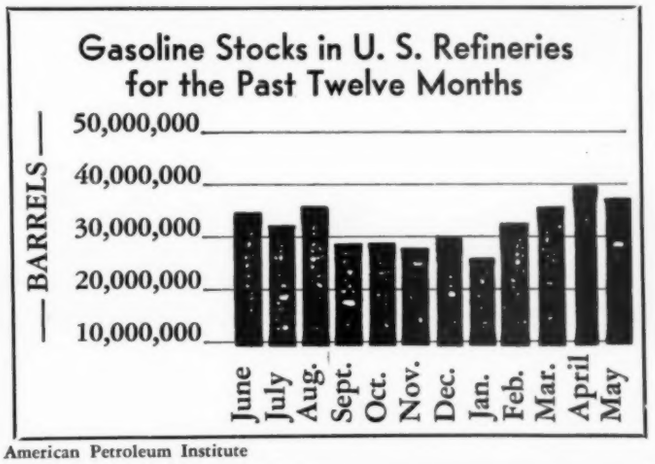
(Figures in barrels)
Furnished by A.P.I.

	Federal Agency Allowable Effective April 1	Week Ended May 26, 1934	Week Ended April 28, 1934	Week Ended May 27, 1933
Oklahoma	476,400	511,050	532,350	383,350
Kansas	122,100	132,900	129,900	105,650
Panhandle Texas		59,400	58,750	44,150
North Texas		55,750	55,950	47,850
West Central Texas		27,100	26,350	19,800
West Texas		143,150	138,350	160,500
East Central Texas		52,150	48,900	58,350
East Texas		475,050	462,150	814,500
Conroe		54,950	50,050	78,000
Southwest Texas		48,250	48,900	48,500
Coastal Texas (Not incl. Conroe)		118,200	113,450	115,000
TOTAL TEXAS	980,700	1,034,000	1,002,850	1,386,650
North Louisiana		25,550	25,900	26,400
Coastal Louisiana		57,150	49,000	41,450
TOTAL LOUISIANA	72,400	82,700	74,900	67,850
Arkansas	32,300	30,600	30,500	29,950
Eastern (Not incl. Michigan)	99,600	101,550	97,650	89,050
Michigan	31,300	32,400	27,100	16,100
Wyoming	32,400	32,100	30,200	27,400
Montana	7,700	7,150	6,950	5,900
Colorado	3,000	3,000	2,600	2,550
TOTAL ROCKY MT. STATES	43,100	42,250	39,750	35,850
New Mexico	45,800	45,850	45,450	36,100
California	462,500	479,200	469,800	484,000
TOTAL U. S.	2,366,200	2,492,500	2,450,250	2,634,550









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for May, 1934

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas									
East Texas	325	323	453	76	264	3600	2	40	Rotary
Duval County	38	31	47	3	12	2300	2	22	Rotary
Refugio County	12	10	15	4	22	5200	2	38	Rotary
Archer County	130	97	167	47	151	660–1800	1 or 2	40	Rot.-Cab.
Conroe	21	20	5	2	13	3000–7400	3 or 4	40	Rotary
Oklahoma									
Oklahoma City	8	6	7	14	34	6500	3	39	Rotary
Kansas									
McPherson	14	10	18	11	36	2900–4300	2	38	Rot.-Cab.
Ellsworth Arch	20	16	24	15	58	3300	4	37	Cable
Harvey County	9	7	5	3	13	3450	2 or 4	37	Rot.-Cab.
California									
Kettleman Hills	6	6	6	4	34	8300	3 or 4	40	Rotary
Long Beach	10	10	7	4	29	7000	3	26	Rotary

Field Activities by States for May, 1934

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1933 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	1	5	0	1	0	4	9	9	28	33	11,682,100
California	42	32	40	28	44	37	42	30	187	183	173,126,800
Colorado	1	1	1	....	....	....	2	2	45	44	954,900
Illinois	2	1	2	....	....	....	7	3	6	11	4,250,000
Indiana	10	1	4	....	....	....	1	1	37	31	730,000
Kansas	62	62	43	41	94	49	53	32	147	124	41,927,700
Kentucky	13	4	6	4	....	....	2	1	42	52	4,610,000
Louisiana	54	62	35	45	83	60	91	68	179	159	24,487,800
Michigan	40	20	32	17	38	42	98	103	137	153	7,790,800
Mississippi	3	4	0	2	....	....	5	6	11	16	Gas Prod.
Montana	12	10	11	7	....	....	10	7	41	49	2,128,700
New Mexico	6	10	5	9	....	....	13	8	56	60	13,086,600
New York	....	....	....	..	....	....	0	2	1	2	3,150,000
Ohio	87	44	62	31	....	....	46	40	163	160	4,300,000
Oklahoma	179	156	126	126	174	206	107	121	397	451	181,133,200
Pennsylvania	20	43	16	38	....	....	37	31	117	95	12,690,000
Texas	879	750	661	561	1188	721	413	300	1201	873	396,993,600
West Virginia	21	33	18	25	....	....	29	31	61	67	3,825,000
Wyoming	7	2	6	2	....	....	12	10	72	67	11,211,000
Total	1439	1240	1068	937	1621	1119	977	843	2928	2730	898,078,200

PROGRESS OF MAJOR PIPE LINE WORK

SIX of the 12 pumping stations on the Iraq Petroleum Company's pipe line are being completed and this month officials of the company expect to start filling the line. Three to four months will be required for filling and testing the line and in the meanwhile the remaining six stations will be constructed. First crude will be delivered to the Tripoli terminal possibly by October 1 and the Haifa terminal will be in operation by the end of the year. It will be the first of next year before the line will be operating to its full capacity of 85,000 bbl. daily.

Three of the 12 pumping stations will be on the main line, four on the northern line, of which Tripoli is the terminal, and five on the southern line, of which Haifa is the terminal. Of the 24 pumps required and already delivered to the station sites, 12 have been installed and are ready for use. Construction of tanks at the Tripoli terminal has been completed and work is under way on the tankage at the Haifa terminal.

Three submarine lines are being laid at Tripoli and two at Haifa.

The total length of the Iraq pipe line is approximately 1350 miles, being constructed of 12-in. pipe except for 200 miles of 10-inch. Laying of the line was completed late last year.

●

The Great Lakes Pipe Line Company, whose gasoline transmission system extends from Tulsa and Ponca City in Oklahoma, north to Kansas City, Missouri, Des Moines and Council Bluffs, Iowa, Chicago, Illinois, and Minneapolis, Minnesota, is constructing several loops to the line between Kansas City and Des Moines that will total approximately 188 miles. A. O. Smith electric-welded 8-in. pipe is being used. The loops are being made to reduce working pressure in the line, which has been around 800 lb. and which, officials of the company believe, is uneconomical. H. C. Price, Inc., Bartlesville, Oklahoma, is the welding contractor. The work probably will be completed by July 1.

Being in the middle of the line, the loop will not add to the capacity and no additional stations are to be constructed, it is announced. The new line is being laid merely to correct an operating problem, it is pointed out.

●

The Pecos Valley Gas Company, Dallas, Texas, subsidiary of the Consumers Natural Gas Company, plans to construct a 40-mile gas line of 6-in. and 8-in. welded pipe from Carlsbad, New Mexico, to the Eunice area in Lea County. The Pecos Valley Gas Company operates approximately 125 miles of transmission and gathering lines between Carlsbad and Roswell, supplying natural gas to many towns in the Pecos River Valley. The new line will be built to enlarge the company's available supply of natural gas.

●

Officials of the Hoffman & Page Company, Eastland, Texas, announce they will lay a 10-mile, 3-in. natural gas line from the Pueblo gas area in northeastern Callahan County, Texas, to the Octane Refining Company's plant near Baird, Texas.

●

The Danciger Oil and Refining Company, owner and developer of the Pledger field in Brazoria County, Texas, proposes to build a 10-in. welded gas line from that field to Houston, a distance of approximately 50 miles. According to present plans, the line will serve industrial users and will represent an investment close to $450,000.

●

The Billings Gas Company, Billings, Montana, is enlarging its trunk line from Billings to the Yellowstone River crossing southeast of Laurel. A sum approximating $275,000 will be expended for that work and the improvement of the company's distributing system. The Great Northern Tool and Supply Company, Billings, has been awarded a contract to weld 14 miles of line. A. O. Smith electric-welded pipe is being used on the job.

●

The Uinta Pipe Line Company is reconditioning approximately 200 miles of trunk and gathering lines from Baxter Basin in southern Wyoming and Hiawatha Dome in northwestern Colorado to Salt Lake City, Utah. The line has been in the ground almost six years and in spots is badly pitted from soil corrosion and electrolysis. The pipe is being dug up, cleaned, polished, coated and wrapped. The estimated cost of the work is $300,000.

●

The Illinois Pipe Line Company has abandoned its pipe line system in the Osage field of Wyoming. The system was a small one, the main trunk line being only five miles in length.

●

The Phillips Petroleum Company is constructing a 15-mile vacuum line in the South Burbank field of Oklahoma. The line is expected to be completed by the middle of July. H. C. Price, Inc., Bartlesville, Oklahoma, is the welding contractor.

●

The Texas Pipe Line Company is making a 12-mile extension to its trunk line system in the Texas Panhandle, as well as laying several miles of gathering line. The line will be of 6-in. pipe, connecting the new production in Wheeler County with the Texas' system that previously had its terminus in Gray County. This will be the second pipe line to serve the new Wheeler area, the Humble Pipe Line Company already having a carrier into that district.

●

For some time it has been rumored that a natural gas line was being planned by the Independent Utilities Company, Jackson, Mississippi, to run from Jackson to Muscle Shoals, Alabama. Recent information coming to *The Petroleum Engineer*, from what is considered a reliable source, indicate that this line will not be constructed.

●

The Globe Gas Company, McAlester, Oklahoma, has made application to the Public Works Administration at Washington for a loan of $212,000 to be used for the purpose of building a gas transmission line to serve a group of towns in Pittsburg County not now having gas.

●

Linton, Indiana, has been granted a $75,000 Federal loan for the construction of a natural gas system, Mayor E. V. Bull announces. Rights-of-way between the Sullivan County line into Linton, route of the gas main line, have been obtained and work is to start immediately, it is stated.

"WE ORDER EVERYTHING FOR PIPE LINE WELDING FROM LINDE"

Lindewelding *made time* for this Contractor

HE had the signed contract, and had hired the crew. The pipe was strung out. The line had to be finished on time.

This contractor then sought the assistance of the Linde organization in training welders in Lindewelding.

Such aid is a feature of Linde Process Service.

After two days training the whole firing line was Lindewelding. The daily reports tell the story: first day, 93 welds; second day, 193 welds; third day, 210 welds; fourth day, 218 welds; fifth day, 273 welds. And when the Lindewelding got up to full speed, the cost per joint became unbelievably low.

Pipe line contractors all over the country can tell of similar incidents in which Linde Process Service has helped them to organize their welding operations for greater speed, dependability and profit. This is why so many of them buy *everything for pipe line welding from Linde.*

Let the nearest Linde District Office give you the latest data on Lindewelding and show you how Linde can be of assistance to you.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN CO., LTD., TORONTO

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES • UNION CARBIDE

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

Users of products and processes developed by Units of Union Carbide and Carbon Corporation benefit from a most unique coordination of scientific research with manufacturing, sales and service facilities. You are cordially invited to visit this summer the numerous exhibits sponsored by the Corporation in both the Basic and Applied Science sections in the Hall of Science at Chicago's 1934 A Century of Progress Exposition.

Sales Offices:

Atlanta	Houston	Portland, Ore.
Baltimore	Indianapolis	St. Louis
Birmingham	Kansas City	Salt Lake City
Boston	Los Angeles	San Francisco
Buffalo	Memphis	Seattle
Butte	Milwaukee	Spokane
Chicago	Minneapolis	Tulsa
Cleveland	New Orleans	
Dallas	New York	
Denver	Philadelphia	
Detroit	Phoenix	
El Paso	Pittsburgh	

NRA WE DO OUR PART

THE MONTH'S ACTIVITIES IN REFINING

Per Cent Refining Capacity Operated

Eastern Division, 80.2 Per Cent **Central Division, 69.2 Per Cent** **Western Division, 52.6 Per Cent**

THE Franklin Creek Refining Corporation, Franklin, Pa., is initiating a construction program that will cost approximately $200,000. New installations will include a fractionating tower on the 1500-bbl. crude distillation unit and a 2000-bbl. lube rerun unit. A new fuller's earth burner also will be added to the plant's equipment. The Franklin Creek Refining Corporation is a subsidiary of the L. Sonneborn Sons Corporation.

●

The Arrow Refining Company, Overton, Texas, is building new cooling towers and adding to its office space.

●

A small refinery is being built near Evanston, Wyoming, by R. C. Andre and associates. Crude for topping will be obtained from local wells.

●

The old Guthrie Refining Company plant north of Guthrie, Oklahoma, has been bought by Dr. E. G. Sharp, reconditioned and is in operation, manufacturing gasoline, kerosene, fuel oil and other products. Crude is obtained from the East Lovell field. The plant is of 500-bbl. daily capacity. It originally was built a number of years ago and operated under the name of the Garber Refining Company. L. Grigsby is plant superintendent.

●

The first natural gasoline plant on the Louisiana Gulf Coast will be constructed by the Shell Petroleum Corporation in the Iowa field. Located on the Calcasieu-Jefferson Davis Parish line, the plant will be of the absorption type and will have a capacity of approximately 15,000,000 cu. ft. daily. Equipment is being moved in from abandoned units in other fields.

●

The Elkhorn Refining Company, Osage, Wyoming, is constructing a casinghead gasoline plant of the compressor type to operate in conjunction with its refinery.

●

The Taylor Refining Company plans erecting a 1000-bbl. refinery at Corpus Christi, Texas. Provision will be made for increasing the capacity of the plant to 3000 bbl. at a later date. G. L. Rowsey is head of the Taylor Refining Company.

●

The Continental Oil Company has installed an electric generating plant at its refinery in Farmington, New Mexico.

●

The Crook County Refinery, a new plant at Sundance, Wyoming, started operations recently. Owners of the refinery are Allan Snyder and Andy Poliscy, and kerosene, gasoline, tractor fuel and distillate are being manufactured.

●

Some of the equipment for the new gasoline absorption plant that Gas and Oil Products, Ltd., is to build in the Turner Valley field, Canada, has been received. The plant, to be located at the Mercury lease, will be the second natural gasoline unit in the Turner Valley field. It will be in operation some time this summer and will process wet gas from wells of independent producers. Headquarters for the operating company have been established in Calgary, Alberta.

●

The T. W. Murray Oil and Gas Company is erecting a 30,000,000-cu. ft. gasoline plant in southern Rusk County, East Texas field. The equipment is being moved in from a plant owned by the company in Louisiana. Gas will be supplied by the company's gasser, which has an estimated potential of 40,000,000 to 50,000,000 cu. ft. daily.

●

The Rice Ranch Oil Company of Santa Maria, Calif., is installing a Lachman treating unit in its refinery to operate in conjunction with a Lincoln Clarke cracking unit.

●

The Independent Refining Company of Hynes, Calif., is adding a fractionating tower, condensers and exchangers to its existing equipment.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending May 26, 1934

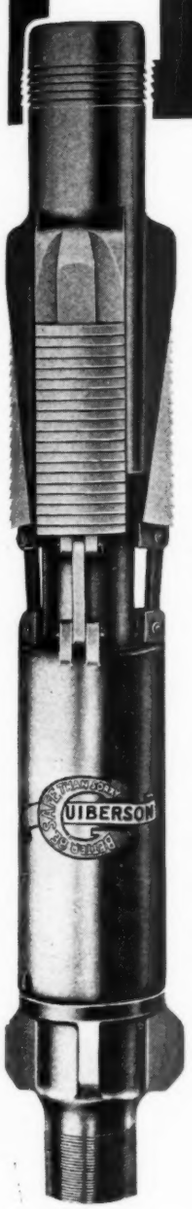
A.P.I. Figures
(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	503,000	86.4	16,979	7,392
Appalachian	93.3	106,000	75.7	1,788	808
Ind., Ill., Ky.	94.6	331,000	78.4	8,804	2,786
Okla., Kans., Mo.	83.7	258,000	66.8	5,552	3,098
Inland Texas	47.6	98,000	58.7	1,366	1,803
Texas Gulf	97.5	465,000	84.2	4,858	5,293
Louisiana Gulf	96.4	101,000	62.3	1,212	1,097
No. Louisiana-Ark.	83.7	57,000	74.0	262	459
Rocky Mountains	66.7	32,000	50.0	1,203	667
California	96.9	454,000	55.2	12,469	*80,607
TOTALS WEEK:					
May 26, 1934	89.7	2,405,000	71.3	54,493	104,010
May 19, 1934	89.7	2,430,000	72.0	54,361	102,896

*Increase over previous week partially due to inventory adjustment.

NEW

Guiberson Type "E" Tubing Catcher



Standard "Type E" Tubing Catcher

"Type E" Catcher with Shoe Anchor

DESIGNED to meet present deep well conditions, the new Guiberson "Type E" Tubing Catcher embodies several improvements over former models.

Slips have large bearing surfaces and are designed to sustain the heaviest loads without distortion of the casing. At the same time they are so proportioned and spaced on the head as to allow a large by-pass area past the head, thus eliminating any possibility of the catcher plugging the casing.

The demand has become almost universal, for an anchor attached to the catcher. In place of the old friction spring which wears out, the new "Type E" has a specially designed anchor whose springs do not come in contact with the casing. Contact is made through special vertical shoes which at all times give a uniform pressure against the casing.

This catcher will positively prevent a fall either while tubing is running in or hanging suspended in the well. Fully patented.

"Better Be Safe Than Sorry"

THE GUIBERSON CORPORATION

BOX 1106, DALLAS, TEXAS

LOS ANGELES: 1304 Security Title Insurance Bldg.

TULSA: 504 Wright Building

NEWARK, OHIO: First and Locust Sts.

GUIBERSON

BETTER BE SAFE UIBERSON THAN SORRY

Recent Developments in the Use of Bottom-Hole Chokes in Oil and Gas Wells

By K. C. SCLATER

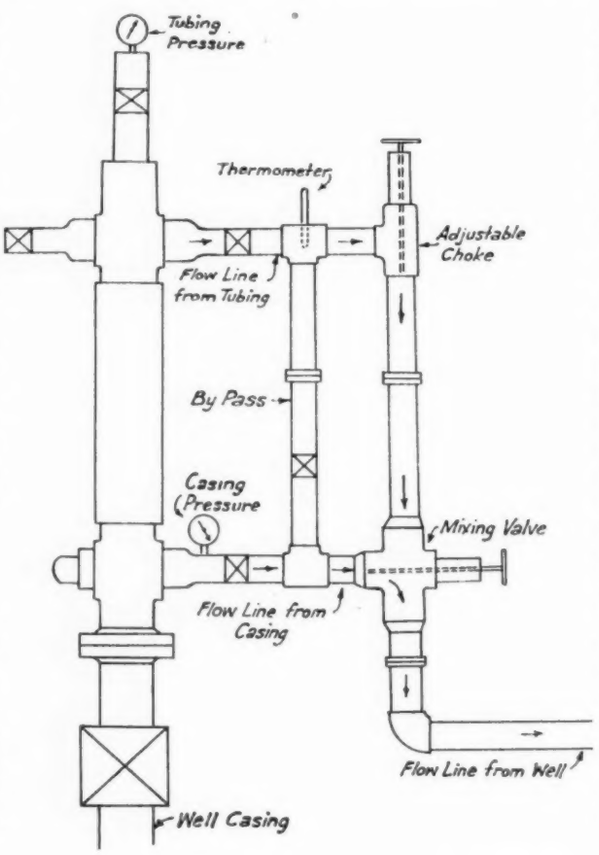
SINCE they first came into use several years ago, removable bottom-hole chokes have undergone steady improvement and design. As a result they now have several different fields of application in connection with the operation of oil and gas wells that were not foreseen when bottom-hole chokes were first thought of.

For the prevention of freezing at wells producing a large volume of high-pressure gas, the insertion of a bottom-hole choke in the tubing and a mixing valve at the surface are now widely used. This use, particularly in the casing of gas wells, has long since passed the experimental stage. It allows the withdrawal of gas in larger quantity than is otherwise possible, without the necessity of applying heat to the gas in any form at the surface. Several articles have appeared in *The Petroleum Engineer* describing in detail the arrangement of fittings in the well for producing gas by this means.

Such uses, however, are not confined to gas wells. Several oil wells in the Gulf Coast have recently been equipped with a bottom-hole choke and mixing valve to increase their flexibility of operation. One well of this group is producing a large quantity of high-pressure gas along with the oil from a depth of about 7000 feet, and is flowing through 2½-in. tubing. It has a closed-in surface pressure of 2675 pounds. Trouble was experienced with freezing at the surface when it became necessary to curtail the well's production to only a fraction of its capacity in order to get it to produce. Freezing was so severe that ordinary methods of producing the well were altogether too hazardous.

A bottom-hole removable choke with a capacity of six million cu. ft. of gas daily was set in the tubing at a depth of 6950 feet. The temperature of the oil and gas at the well head rose from below freezing to 117 deg. fahrenheit. By opening the mixing valve, which is connected into the casing, it was possible to increase the daily rate of withdrawal as desired up to 15 million cu. ft. of gas. Even at this latter volume the temperature of the production was still well above freezing. The production test data taken on the well over a period of three days when the bottom-hole choke and mixing valve were installed are given in the accompanying table. The arrangement of the connections at the well head are also shown on the accompanying sketch. As has been explained in previous articles, the choke is run on a Halliburton steel line. Only one hour and 20 minutes were required for the entire operation of running the choke in, setting it at 6950 ft. and pulling the line back out.

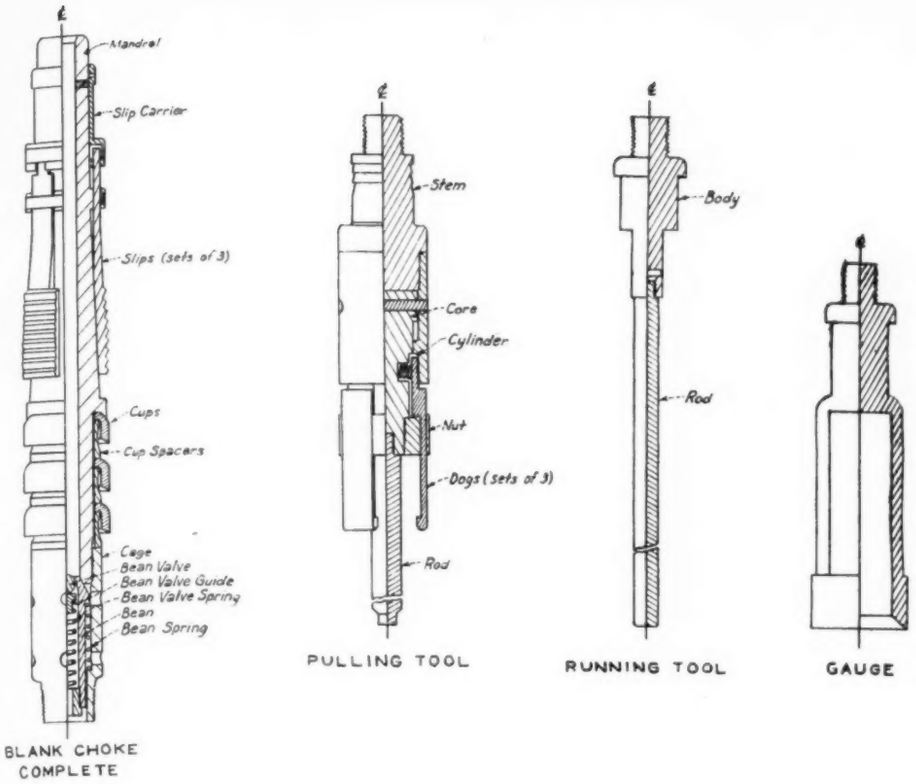
After the choke was set, the well was connected and then was gradually opened up through the tubing by means of an adjustable choke at the surface (see illustration). It will be noted from the table that the maximum rate of flow was six million cu. ft. through a 17/64-in. choke. Before installation of the bottom-hole choke the well had produced at the rate of five million cu. ft. of gas through a 16/64-in. surface choke; thus the bottom-hole choke gave a rate of flow equivalent to that of the surface choke. Another important advantage was gained: the working pressure at the surface was reduced from 2575 lb.—the pressure when flowing through a ¼-in. surface choke—to 450 lb. with the bottom-hole choke. Reduction of the working pressure on a casinghead connection was an important consideration in itself.



Sketch showing arrangement of casinghead connections used in a well of high gas-oil ratio in the Gulf Coast. The well is equipped with a removable bottom-hole choke by means of which, in conjunction with a mixing valve at the surface, freezing is eliminated. Extremely high pressure on casinghead connections is also avoided.

After the well had been flowing for about 15 hours through the tubing, gas from the casinghead was released through the mixing valve into the flow line. The temperature of this gas was higher than that from the tubing and was sufficient to prevent freezing. The hourly changes in pressure and temperature can be noted in the accompanying table. After the well was flowed through the tubing and the mixing valve was opened up to its maximum, a flow of six million cu. ft. was obtained through the tubing and nine million ft. through the casing. Experience shows that at least twice as much gas may be withdrawn from the casing as from the tubing. It is assumed, therefore, that the maximum flowing capacity of the well was limited by the size of the mixing valve, which is only ½-in. in this instance.

By having reduced the working pressure on the casinghead connections a greater factor of safety has been obtained and freezing trouble at the trap has

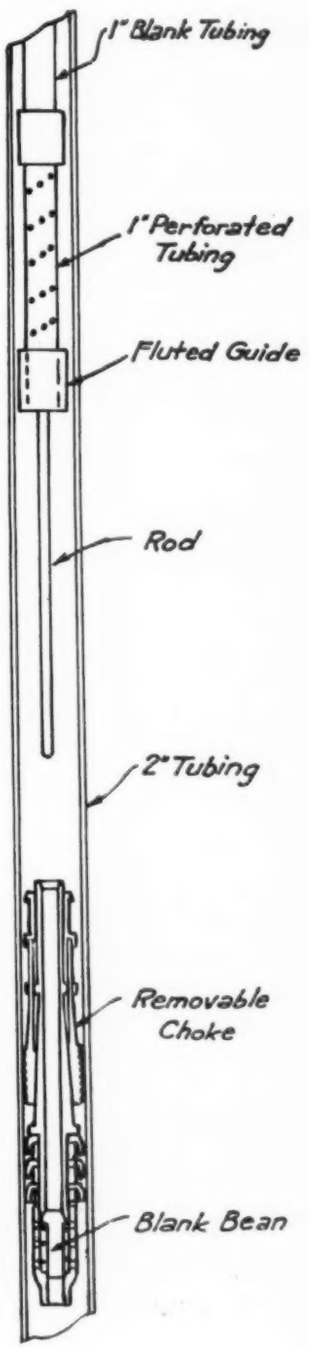


(At left) Sketches showing details of removable blank choke and the tools for setting and releasing it.

(These tools have been designed by the Southern States Company, by whom they are patented).

•

(Below) Sketch showing details of connection used on bottom of 1-in. string of tubing for opening blank choke set inside 2-in. tubing.



been eliminated. In high-pressure areas this is no small consideration.

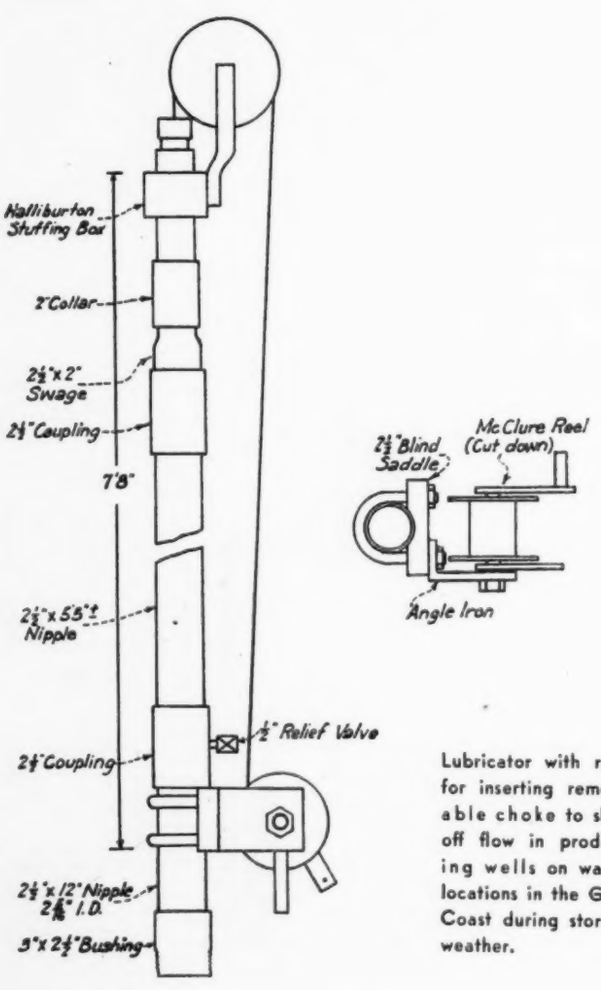
On two wells in the Tomball field similarly equipped with a mixing valve, the rate of production can be varied from about 25 bbl. daily up to at least 125 bbl. daily simply by bleeding off a small quantity of gas from the casinghead through the mixing valve, which in effect slightly reduces the bottom-hole pressure. The tendency toward freezing which was present before installation of the mixing valve and bottom hole choke in these wells, was eliminated; the high working pressures at the surface were also reduced.

Bottom-hole chokes have also recently found a useful application in wells where it is required to run a string of 1-in. tubing into a string of 2-in. already in a well. In a well in the Yates field it was required to run a string of 1-in. inside 2-in. tubing under pressure. There was some objection to connecting the heavy control heads to the 2-in. tubing because of the hazard of snapping off the connection. To overcome this objection a removable blank choke was run to the required depth and the flow of the well shut off; then the string of 1-in. was run. On the bottom of the 1-in. a connection was provided by means of which the blank bean in the 2-in. choke could be depressed when the 1-in. was lowered against it and the flow of the well restored. A perforated nipple about 2 ft. long and a fluted guide, suspended from which was a rod to go inside the blank choke, was run on the bottom of the 1-in. pipe (see illustration). The blank choke, completely plugging the 2-in. tubing, made it possible to run the 1-in. pipe without the use of control heads. Attached to the top of the 2-in. tubing was a simple stuffing box with a sleeve through which the last joint of 1-in. was run. This securely packed off the 1-in. from the 2-in. tubing. When the weight of the 1-in. was lowered against the choke it depressed the bean and allowed the well to flow up through the 1-in. string of tubing. It required a movement of the 1-in. tubing of only two inches to open the bean in the blank choke and allow the well to flow, and a reverse movement of two inches to close it. In this way it is possible to run or pull a small string of tubing inside a larger string against any well pressure without having to work under high well pressure.

Another interesting use is that of changing the length of a string of tubing without any of the hazards due to high pressure. By connecting a short string of small pipe to the bottom of a blank choke the string of tubing can, in effect, be lowered any reasonable desired amount. This was accomplished in a high-pressure well in the Conroe field. About 52 ft. of ½-in. pipe was connected to the bottom of a removable blank choke, which had a ⅛-in. bean; the blank choke, with the small pipe suspended from it, was set just above the perforations in the 2½-in. tubing. When set the ½-in. became an extension of the 2-in. flow string. In this case, the cross-sectional area of the ½-in. was ample for the size bean used.

Another somewhat novel use for bottom-hole chokes has been found. Flowing wells in water locations on the Gulf Coast are always confronted with the danger of connections being broken off during storms. When such a mishap occurs, damages may be assessed against the oil well owner should oyster or shrimp beds in the vicinity of the well become polluted. To prevent damage of this kind wells are being equipped with a lubricator and removable blank choke attached to the tubing head (see illustration). The blank choke is all set up ready for running quickly to a depth of about 200 ft. whenever a storm warning is received. This will shut off the flow of the well and no damage will be done should the connections be knocked off during the storm. As soon as the storm is over the chokes are pulled and the well is put back on production. The lubricators are 2½ in. in diameter by 8 ft. long and plans are now being made to equip a group of 25 wells at Houma, Louisiana. It takes about five minutes to set the choke and about ten minutes to remove it. The surface closed-in pressure of these wells is about 1000 pounds.

A removable blank choke for use in 7-in. casing, whereby a string of tubing can be run inside casing without facing the risk of high well pressure, has been designed by the Southern States Company, who specialize in work of this kind. A string of tubing can be reset to any desired depth if necessary for better well operation. No extreme well pressures need be faced in this operation. In addition, a well can be produced with greater flexibility, more efficiently, and with a greatly reduced working pressure at the casinghead. This development opens up great possibilities that are bound to find a wide outlet in deep well producing operations.



Lubricator with reel for inserting removable choke to shut off flow in producing wells on water locations in the Gulf Coast during stormy weather.

Table of hourly production test data showing increase in temperature (sufficient to prevent freezing) and reduction in working pressure at the casinghead connections obtained in a well by using a removable bottom-hole choke at 6950 ft., and a mixing valve at the surface.

Time	Hourly Production Oil bbl.	Hourly Production Gas M. cu. ft.	Tubing Pressure lb.	Casing Pressure lb.	Temp. in Tubing Flow Line deg. fahr.
8 p.m.[1]	.....	.....	450	2625	.....
9 p.m.	5.28	250	450	2625	.....
10 p.m.	2.64	250	450	2600	.....
11 p.m.	2.64	250	450	2575	.....
12 p.m.	1.32	250	450	2575	.....
1 a.m.	1.65	250	450	2575	82
2 a.m.	2.97	250	450	2575	84
3 a.m.	2.31	250	450	2575	84
4 a.m.	2.97	250	445	2575	85
5 a.m.	2.64	250	445	2575	85
6 a.m.	2.64	250	450	2575	83
7 a.m.	2.31	250	450	2575	84
8 a.m.	2.97	250	450	2570	83
9 a.m.	1.32	250	450	2550	84
10 a.m.	4.62	250	450	2550	84
11 a.m.[2]	1.32	250	450	2550	84
12 M	2.64	375	500	2500	86
1 p.m.	3.30	375	500	2500	88
2 p.m.[3]	3.30	375	450	2450	91
3 p.m.	10.56	500	500	2425	96
4 p.m.	5.94	500	475	2425	97
5 p.m.	.99	500	475	2425	98
6 p.m.	4.29	500	475	2425	98
7 p.m.	5.28	500	475	2425	98
8 p.m.	5.28	500	475	2425	98
9 p.m.	4.62	500	475	2425	98
10 p.m.	5.94	500	500	2425	99
11 p.m.	8.58	500	500	2425	100
12 M	10.56	500	450	2325	102
1 a.m.	6.60	500	450	2320	104
2 a.m.	4.95	500	440	2310	103
3 a.m.	4.62	500	425	2305	103
4 a.m.	4.95	500	420	2295	103
5 a.m.	6.60	500	415	2275	103
6 a.m.	3.96	500	415	2260	104
7 a.m.	3.96	500	415	2260	104
8 a.m.	6.60	500	415	2255	104
9 a.m.	7.92	500	400	2250	105
10 a.m.	5.28	500	400	2250	105
11 a.m.[4]	6.60	562	450	2150	108
12 M[5]	10.56	625	450	2150	110
1 p.m.	11.88	625	475	2150	112
2 p.m.	7.92	625	475	2150	112
3 p.m.	7.92	625	475	2125	114
4 p.m.	7.26	625	500	2125	115
5 p.m.	7.26	625	500	2125	115
6 p.m.	9.24	625	500	2125	116
7 p.m.	6.60	625	500	2125	115
8 p.m.	7.92	625	500	2125	114
9 p.m.	10.56	625	475	2125	114
10 p.m.	3.96	625	475	2125	115
11 p.m.[6]	7.92	625	475	2125	115
12 M	9.90	625	475	2125	115
1 a.m.	3.30	625	490	2050	114
2 a.m.	5.28	625	505	2025	116
3 a.m.	7.26	625	510	2010	117
4 a.m.	7.26	625	510	2000	117
5 a.m.	5.28	625	510	1995	117
6 a.m.	5.28	625	515	1930	116
7 a.m.[7]	9.90	625	515	1925	114
8 a.m.	9.90	625	515	1920	114
9 a.m.	2.64	625	475	1975	114
10 a.m.	6.60	625	500	1950	114
11 a.m.	6.60	625	500	1950	116
12 M	7.92	625	500	1950	116
1 p.m.	10.56	625	500	1950	116
2 p.m.	5.28	625	500	1950	116
3 p.m.	5.28	625	500	1950	114
4 p.m.	4.62	625	500	1950	114
5 p.m.	5.94	625	500	1950	114

[1]Gas volume six million cu. ft. daily through tubing with 17/64-in. bottom-hole choke set at 6950 ft.

[2]Gas volume increased to nine million cu. ft. daily at 11 a.m. by opening mixing valve.

[3]Gas volume increased to 12 million cu. ft. daily at 2 p.m. by further opening mixing valve.

[4]Gas volume increased to 15 million cu. ft. daily at 10:30 a.m.—mixing valve wide open.

[5]Gravity of oil at 11:30 a.m. was 50.8 at 60 deg.

[6]Gravity of oil at 11 p.m. was 53.8 at 59 deg.

[7]Gravity of oil at 7 p.m. was 53.3 at 60 deg.

Blending Facilities at Gasoline Trunk Line Station

Phillips Pipe Line Co. Adds Equipment at Paola, Kansas

By FRANK H. LOVE

Paola, Kansas, station. Heat exchanger and overhead working tank shown in the foreground

TO facilitate general operations and to relieve the Kansas City and St. Louis terminals of frequent overtaxing, the Phillips Pipe Line Company recently added gasoline blending equipment at the Paola, Kansas, station. This station is located at the junction of the company's gasoline carrier, one branch, a 6-in. line, going to Kansas City, the other, an 8-in. line, terminating at St. Louis. Until now blending of the various grades of gasoline has been done solely at Kansas City and St. Louis.

To provide necessary additional tankage for blending and storing, one 80,000-bbl. standard tank and one 20,000-bbl. spheroid tank were constructed. The former is used for blending and is equipped with a blending spider, the roof being of the pontoon-type. The spheroid tank is for storage of high-gravity gasoline and carries a working pressure of 15 lb. per sq. inch. A feature of this tank is a stationary gauge line equipped with a glass view-plate, making it possible to take readings without releasing the pressure. Storage facilities existing prior to the new installations consisted of two 80,000-bbl. standard tanks with floating roofs, thus increasing the total capacity to 260,000 barrels.

All tanks are situated on an elevation several hundred feet from the station and the gasoline gravitates to the pumps, thereby eliminating the need for line suction. The tanks are gauged hourly.

An 8-in. line connects the new storage with an 8 by 10 centrifugal blending pump driven by a four-cylinder gas engine housed in a 13-ft. by 6-ft. brick structure.

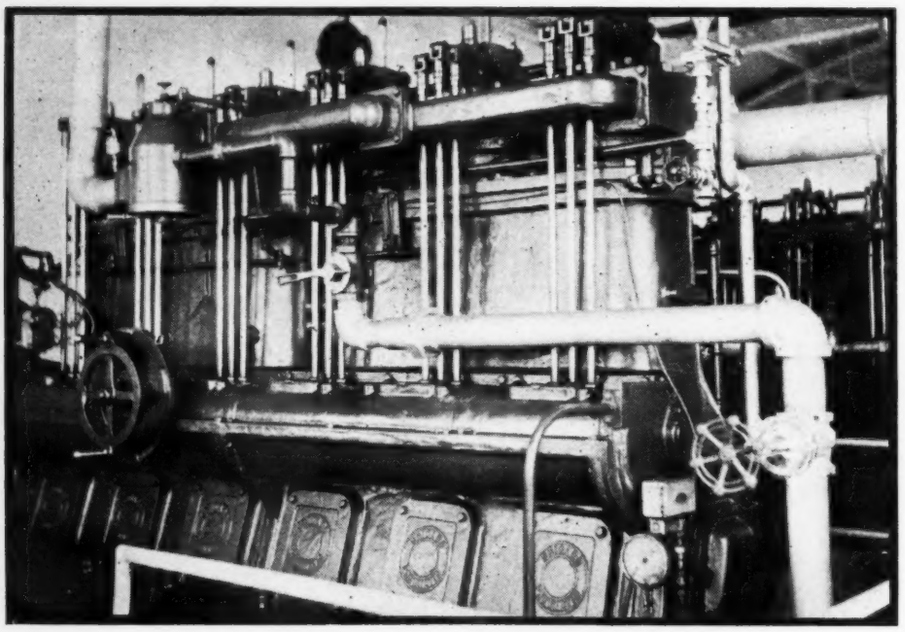
A manifold of advanced type, equipped with high-pressure gate valves and all necessary auxiliaries, was built to provide for the requirements of the blending process.

The Paola station, one of the key stations on the Phillips system, completed and put into operation in 1931, is, from the viewpoint of both design and equipment, worthy of description. Two radical departures from general pipe line practice were introduced at this as well as other Phillips stations: fueling of the prime-movers (gas engines) with butane, and the driving of centrifugal pumps through gear increasers.

Butane, once virtually a waste product, but employed to a certain extent for "running in motors" and for other stationary gas engine installations, was put to use by the Phillips organization following experiments that led to the belief it would make an excellent fuel for gas engines, a belief, officials of the company state, that has been fully borne out during the last three years.

The butane is stored in three horizontal tanks, each having a capacity of 24,706 gallons. Stored in liquid form, it requires vaporization before it can be used as an engine fuel. A special vaporizer is employed for this purpose, except during the summer months when high atmospheric temperature causes the butane to vaporize in the storage containers. The vaporizer is a shell and tube arrangement and hot water from the engine jackets is used as the heating medium. Hot water circulates through the coils, while the butane enters the shell outside the coils and is there vaporized. The vaporizer is equipped with two regulators, one of low and the other of high pressure. By means of these the butane is reduced to a gas of 8-oz. pressure. The regular course of the butane is from the storage tanks to the heat exchanger where it vaporizes. From there it passes to the high-pressure regulator, thence to the low-pressure regulator, through a drip tank and on to the engines. A kidney float regulates the level of butane in the vaporizer.

Prime-movers consist of two 265-hp., 6-cylinder gas engines developing a speed of 360 r.p.m., and one 300-hp. 8-cylinder gas engine developing a speed of 560 revolutions



Gas engine of the type in use on Phillips Pipe Line System. Butane is used as fuel

per minute. These engines are connected to centrifugal pumps through gear increasers. The pumps are 4-stage units, each having a capacity of 30,000 bbl. per 24-hour day. As an indication of the increased volume to be derived from the use of gear increasers, the speed of the pumps driven by the 265-hp. engines is stepped up from 360 r.p.m. to 3480 r.p.m., and the speed of the pump operated by the 300-hp. unit from 560 r.p.m. to 3480 revolutions per minute. A flexible coupling, placed between the flywheel and gear increaser, absorbs shock which otherwise would reach the pump. Since gasoline is the fluid run all pumps are equipped with metallic packing, a lead composition having a certain amount of elasticity and at the same time being sufficiently hard to "seal off."

The fire-wall between the engine and pump room is vapor-proof, and non-shatter glass windows in the wall make it convenient for operators in the engine room to read pressure gauges in the pump room.

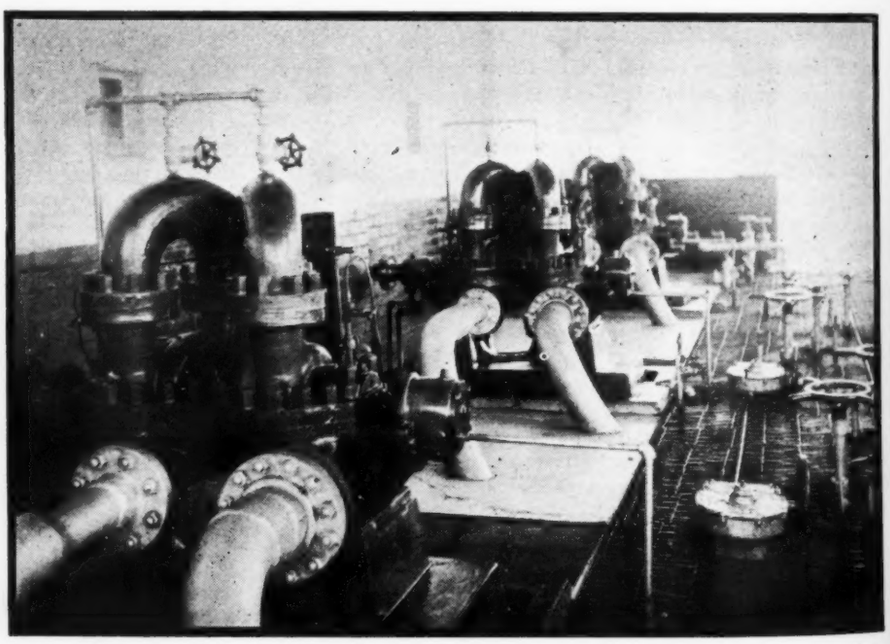
The engines start on 135-lb. to 200-lb. air pressure supplied by a 5-hp. motor-driven air compressor operating on current from a generator. Should the station be down, a 10-hp. gasoline engine is available for charging the air tanks, four in number and situated in one end of the engine room.

In accordance with the trend in pipe line station design, automatic switches and recording instruments necessary for safe operation are a part of the equipment of the Paola station, which is operated on a variable line pressure of 500 to 900 lb., a mercoid switch being employed to ground the magneto and automatically shut off the engines when the pressure becomes too great. Automatic switches also control the water temperature in engine jackets and the flow of lubricating oil. When jacket water becomes too hot or oil flow is retarded to a dangerous point the engines are automatically cut off. Gauges for indicating and recording pressure are on both the incoming and outgoing lines, and a venturi meter registers the rate of flow and the amount of gasoline passing through the line.

When the station was originally constructed a louver-type tower was used for cooling engine water, but this system has been abandoned and a heat-exchanger of the enclosed type installed. Centrifugal pumps, operated off the flywheel of the engines by means of a belt, pick up the hot water from the engine jackets and force it through the heat-exchanger to a 5-bbl. overhead tank, from which it gravitates to the engines. Gasoline, running through a heat-exchanger counter-current to the water, serves as the cooling medium.

Electricity for lights and other purposes is supplied by two 7.5-kw. d.c. 125-v. generators, developing 1200 r.p.m., and operated off the gas engines. An auxiliary gasoline engine of 10 hp. is used as a standby unit and pressed into service when the station is down. This engine is connected to a 5-kw. 125-v. generator, developing a speed of 1150 r.p.m., and is the same unit used for driving the air compressor when the prime-movers are not in operation.

Because of the inflammable nature of the fluid being pumped every precaution has been taken against the possibility of fire. In addition to having the engine and pump rooms separated by a vapor-proof fire-wall, all wiring in these two rooms is housed in overhead conduits; wiring to outside buildings is underground and encased in lead-covered cables. Also fuel lines are buried beneath the concrete floor. Fire-fighting equipment consists of a chemical cart, numerous hand-size chemical containers, and a fire plug in close proximity to the station fire hose and reel.



Centrifugal pumps, driven by gas engines through gear increasers

Refining Western Kansas Crude Oil*

By
CARL W. BERGER
Assistant Chief Chemist
Globe Oil and Refining Company
of Kansas, McPherson, Kansas

REFINING Western Kansas crude oil presents problems that, though not particularly difficut as to solution, are characterized by their variety. The chemical and physical composition, the adaptability to refining, and the nature of the individual eccentricities of the various problems are, collectively, quite diversified. Even when confined to a relatively small producing area, and subject to one given type of refining operation, numerous problems confront the refiner.

In Western Kansas, we are dealing, in general, with two types of crude oil; the crude from the McPherson area and the Chase (Rice County) crude. Of course, there are minor differences in the crude produced in different pools in each area, and even differences in the crude from different wells in the same pool, but, speaking from the refiner's standpoint, there are these two types mentioned. The Globe refinery in McPherson segregates McPherson crude from the Chase crude by the simple expedient of placing it in different tanks; but when actually refining the two, the problems become more serious. Certain results can be expected from one crude that cannot be expected from the other; precautions must be taken with one that need not be taken with the other; different modes of operation are advisable when switching from one to the other.

This can be partly explained by a brief examination of the differences between the two crude oils. McPherson crude, as run to the stills in the Globe refinery, has a Baumé gravity of from 36 to 39, while that of Chase crude runs from 41 to 44. The percentage of gasoline and naphtha in the Chase crude that is refined here, is somewhat higher than in the McPherson crude. The kerosene content is about the same. They are both mixed base crude oils, having characteristics of both paraffin base and asphaltic base crudes. They are not particularly adapted to the manufacture of either lubricating oils or tars, although either or both have been successfully manufactured. The sulphur content of the crudes is approximately the same, yet strangely enough, the sulphur compounds give trouble in one crude while in the other they give very little trouble. The sulphur compounds in the Chase crude are not so firmly attached as in the other crude, for a simple distillation will break them down, producing quantities of hydrogen sulphide (H_2S) gas, which is always unpleasant and quite corrosive; therefore, in refining Chase crude oil, more ammonia must be fed to the fractionating towers and condensers, the lighter cuts must be caustic-scrubbed to prevent the oxidation of the H_2S into free sulphur in the rundown tanks, and the H_2S carefully removed before doctor-sweetening the straight-run gasoline. Otherwise it would "kill" the doctor solution. Even after removal of the H_2S, many sulphur compounds are left in the gasoline, necessitating a more vigorous sweetening at a higher cost per barrel.

In doctor-treating the cracked gasoline from Chase crude oil, a proportionately higher percentage of combined sulphur is also found, composed mainly of the lower mercaptans. To prevent the removal of the natural gum inhibitors in the gasoline, and at the same time thoroughly remove undesired sulphur compounds, presents a nice problem of balancing caustic concentrations in the plumbite solutions.

Partially to compensate for the difficulty with the sulphur compounds in the Chase crude, it is found that the salt, or sodium chloride content of this oil is much lower than in the McPherson type of crude. Chase crude averages about 14 grams of salt per barrel coming from the storage tanks, while the McPherson averages almost 130 grams, or more than ¼ lb. of salt per barrel. Now this salt is, in the main, carried in the oil itself and not in the water with which the petroleum is contaminated. The salt crystals are protected by a coating of paraffin or asphalt, making the simple water washing of crude ineffective so far as salt removal is concerned. It can be removed by treating agents such as Tret-o-lite or Dehydro along with a heat and pressure treatment, but this again runs into considerable expense when 10,000 or more bbl. per day is to be handled. If some action is not taken, however, this salt will be deposited in the heat exchangers and other equipment of the plant, gradually building up until it chokes the passages and prevents the flow of oil, eventually necessitating an expensive shut down. At the present time, the Globe Oil & Refining Company is experimenting with a novel and apparently successful method of handling the problem; that is, by flashing off the last traces of water carried in the crude. This is carried out in the debutanizing equipment, and while it necessitates a deeper cutting of the primary crude with reference to the very light ends, it pays large dividends by eliminating the salt-clogging difficulties. The removal of the water keeps the salt within the body of the oil, preventing its precipitation on the walls of the plant equipment, where otherwise it would deposit at the high temperatures experienced in that equipment.

The octane or anti-knock rating of both McPherson and Chase crude straight-run gasolines is not exceptionally high. For this reason, they must be handled carefully to keep the octane rating of this straight-run gasoline as high as possible. In the manufacture of cracked gasoline, we are not so concerned with the potential octane value of the crudes, but nevertheless, the chemical composition of the crude must be taken into consideration, and the cracking equipment adjusted to produce the highest octane product possible from the type of crude being run.

Further, in the blending of ethelyzed gasolines, we find peculiarities to be overcome, since the lead susceptibility of the different refinery cuts vary with startling abruptness.

The Globe refinery is fortunate in having highly flexible cracking and treating equipment, in that it is able to manufacture much more highly satisfactory products than would ordinarily be possible. The combination of multicoil cracking, Lachman (or zinc chloride) vapor phase treating, and well engineered heat-exchange equipment, enable this refinery to produce cracked gasoline and other products of a nature and

* This is the substance of a paper read at the A.P.I. District Meeting held at McPherson, Kansas, May 12, 1934.

state of refinement that compare favorably with any product on the market, regardless of from what locality or from what type of crude oil, and at a reasonable cost per barrel.

Now, let us examine more closely, some of the plant equipment and methods of plant operation in use at the Globe refinery.

The cracking equipment used is of the Winkler-Koch multicoil combination type. There are two high-pressure stills; one handling topped crude, gas oil, slop, etc., and operating ordinarily at from 930 to 950 deg. fahr. outlet temperature and about 400 lb. outlet pressure, the other handling lighter charging material such as cold naphtha, stripper bottoms, etc., and operating at from 950 to 1000 deg. fahr. outlet temperature and 300 to 500 lb. pressure. When running McPherson crude the temperatures are approximately the same as for the Chase crude. After passage through the cracking furnace, the hot vapors from each still is led into a common transfer line and into a vapor separator. The lighter fractions are taken from the top of this tower and fuel oil from the bottom. The fuel oil is further reduced in a vacuum tower before being pumped to a tank.

The lighter material is fractionated by an 11-ft. by 75-ft. 15-bubble tray bubble tower, from the top of which HPD is removed at 400 deg. fahr. temperature, and 40 lb. pressure. The hot vapors pass into the contact tower of the Lachman treating system where they are acted upon by zinc chloride ($ZnCl_2$) solution and superheated steam in the vapor phase at 370 to 380 deg. fahr. temperature and 35 lb. pressure. The products formed are hydrochloric acid, polymerized hydrocarbons, zinc sulphide, and treated cracked gasoline. The polymers are drawn off, along with some unused $ZnCl_2$ and the zinc sulphide, and pumped to the $ZnCl_2$ recovery plant, where the $ZnCl_2$ is separated, concentrated, and purified for further use. Most of the HCl formed in the contact tower passes overhead with the treated gasoline. Two lime rock towers are set in series on the outlet side of the treating tower, their purpose, of course, being to neutralize the HCl formed and remove it as $CaCl_2$. The contact tower and other fittings are of brass or other acid-resisting material. The gasoline, after passing through the lime rock, is further neutralized by a stream of ammonia gas, then passes to a final bubble tower, 9 ft. by 42 ft. and having 12 decks, operating at 40-lb. pressure. This tower removes, by fractionation, the last traces of gum-forming constituents and other unstable, undesired hydrocarbons. The vapors from the top of this tower pass through a heat exchanger and condenser and thus to rundown tanks, where the cracked gasoline is picked up by the doctor-sweetening system for further sweetening before running to storage tanks.

Other points of interest in the plant are too numerous for all to be mentioned here. The heat-exchange equipment is particularly interesting in that the operation of the plant is continuous, without rerunning stills or other intermediate steps. The entire process is carried at the proper temperatures mainly by heat transfer, and without the addition of further heating except for the amount of steam used.

Steam is generated by two 500-hp. Heinie boilers and one 500-hp. Vogt boiler, operating at 250 lb. pressure, and carrying approximately 80 deg. of superheat at the boiler house. Additional superheat is available in the plant through the use of a separate superheater. The water-treating equipment is of the Graver hot process type, being well adapted to the well water used exclusively at this plant.

The vapor recovery plant is of the compression type, operating at approximately 250 lb. pressure. There are four compressors rated at 4,500,000 cu. ft. per 24 hours. Two stabilizing towers, one for cracked and straight-run light vapors, and the other for treated pressure distillate insure a flexibility for the production of correct seasonable gasolines.

This brief resumé of the equipment and mode of operation in use at the Globe refinery in McPherson, along with an outline of the problems encountered in handling these two types of Western Kansas crudes, may serve to give some idea as to what may be expected in the further development of the oil industry of this State, both from the production and the refining standpoints.

The above photograph shows the exhibit (consisting of a miniature wire rope mill and an automatic railway system) at the International Petroleum Exposition of the Union Wire Rope Corporation, Tulsa, Oklahoma. Inspecting the exhibit are officers and directors of the company. Reading left to right they are: M. G. Ensinger, Kansas City, Missouri, vice-president; R. H. Bartlett, Tulsa, president; H. L. Donnelly, Kansas City, general counsel; H. R. Gruber, Tulsa, vice-president; J. A. Undercofler, Oklahoma sales representative; H. Ed Frye, Kansas sales representative; Herb R. Cutlip, Texas sales representative; Senor Enrique O. Chapa, Mexico City, representante exclusivo para la Republica Mexicana for Union Wire Lines; J. H. Hatch, Tulsa, secretary-treasurer; E. A. Reedy, Kansas City, director; M. B. Hansell, Kansas City, chief electrician; and W. O. Ireland, Kansas City, assistant electrician.

Exterior view of compressor station No. 3 on Western Gas Company's line.

By
J. F. WEADOCK

Modern Stations on Western Gas Line

ALTHOUGH 217 miles of trunk line have been added to the Western Gas Company's transmission system in Arizona, delivery of gas to the various consuming centers is being accomplished with the use of the initial number of compressor stations. The original plan of Western Gas officials called for the construction of an additional station to lighten the load between Douglas and Phoenix, but upon completion of the extension between those cities early this year, it was concluded that increased pressures would sufficiently care for existing demands and no new installations would be required. Consequently, the four stations built in 1931, two of which are east of El Paso, Texas, another in the vicinity of that city and the fourth 120 miles west, are carrying the load.

The stations are numbered from one to four, beginning at the producing field in Lea County, New Mexico. The distance between stations No. 1 and No. 2 is 65 miles, between No. 2 and No. 3 stations 70 miles, and between No. 3 and No. 4 stations 110 miles. Between station No. 4 and Phoenix is the recently laid line of 217 miles. The line between the producing field and station No. 3 is tested for 500-lb. maximum pressure, that between No. 3 and No. 4 for 750-lb. maximum pressure, and the extension from Douglas to Phoenix, which goes via Tucson, will carry a load of slightly more than 600-lb. pressure. At present the latter part of the line is operating on approximately 300-lb. pressure, subject to certain variations caused by a shifting load.

At Tucson deliveries are made at two gates. Through one passes the gas intended for domestic use, through the other that for industrial purposes. The former is introduced into the main line at 20-lb. pressure, while the line carrying the industrial gas has an operating pressure of 15 pounds. Pressure at the delivery gate in Phoenix is approximately 270 lb. at the present time. This is the farthest point from the producing field.

With the completion of the 217-mile extension the Western Gas Company has in operation a total of more than 600 miles of gas line, running from Lea County, New Mexico, through El Paso, Texas, to Cananea, Mexico, Douglas, Bisbee and Tucson, Arizona, to Phoenix, the capital of the latter state.

The four compressor stations that control the flow of gas on its westward journey are complete in every detail, each having its own machine shop, warehouse, living quarters, recreation hall and, in districts where public schools are not available, its own school for the children of employes.

Stations No. 1 and No. 2 each contain three Cooper-Bessemer 19x24x11 compressors. Station No. 3 has three similar units, except that the intake pressure is 325 lb. and the compressor cylinder diameter is 9½ instead of 11 inches.

Station No. 4 has two units like those in No. 3. These compressors are rated at 760 hp. at 180 r.p.m., working with a compression ratio of two and one-half to one.

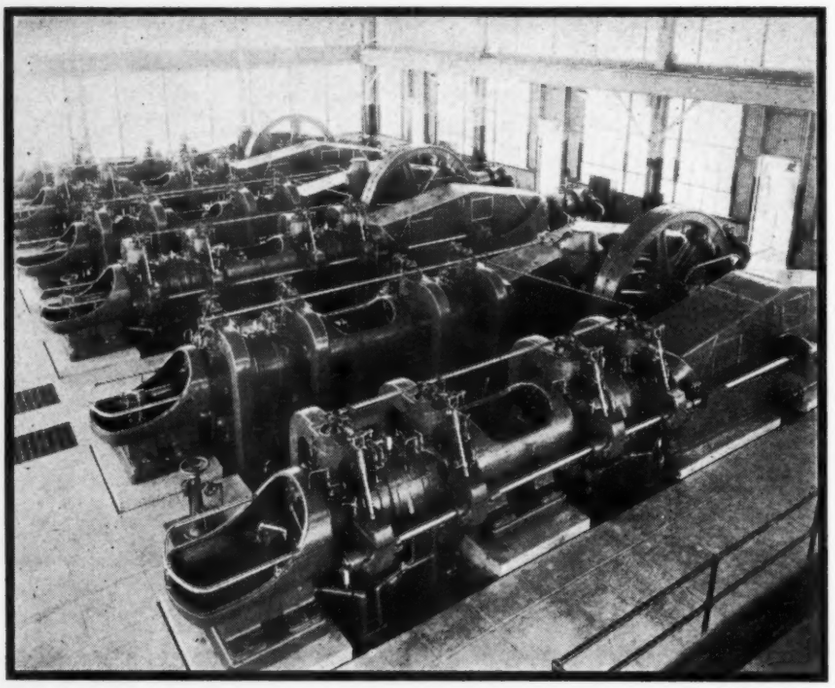
Each station is constructed with a structural steel frame, covered with corrugated asbestos and designed to give the maximum of light and ventilation. The operating floor is about five ft. above the ground level, while all the piping is in a well-ventilated and well-lighted basement.

Installed in each of the compressor buildings is a traveling crane capable of handling any piece of machinery or equipment and in each floor a well has been constructed that will permit the crane to place any single piece of equipment directly on a truck driven into the basement. Another feature in connection with the floor construction is the severance of the operating floor from the engine foundations, thereby eliminating vibration.

The compressor engines are double-acting, twin tandem gas engines. They are 4-cycle, dual ignition and are started by air pressure. Each engine has its own fuel header and gas is introduced outside of the air line, which delivers screened air from the outside of the building.

The exhausts are water-cooled and of the swirl type to minimize the noise and these are set on rollers to take care of the expansion. Lubricating oil is circulatd and cleaned in a filter located in the operating floor.

The compressors are direct-connected, double-acting, and are equipped with unloaders. They are designed to operate with a compression ratio of two and one-half to one. The suction and discharge piping is so arranged from each compressor cylinder that any combination of cylinders can be used with any after-cooler. The after-coolers are of the water-tube type and cool the gas line to the normal line temperature. The fuel gas meters and regulators are located in a small building near the after-coolers and supply low-pressure gas for compressor fuel and for use in the residences.



Interior of compressor station No. 3, El Paso, Texas, showing Cooper-Bessemer units

All the compressors on the Western Gas Company's line are alike except in a few minor details, such as at Station No. 3, which has only one auxiliary electrical unit, as electric power is usually purchased from the local power company. All other stations contain two complete electrical units, with direct-driven generators having direct-connected exciters.

Another feature of the compressor stations is the complete machine shop and warehouse unit at each. The widely-spaced stations and the nature of the country in which they are situated make it mandatory that each be independent in every respect. It is with this in mind that the machine shops have been constructed and equipped. Equipment at each consists of a 24-in. lathe with a 12-ft. bed, a pipe-threading machine, electric hack saws, grinder, drill press, electric-welding and complementary equipment plus a number of other auxiliary tools that make the shop capable of caring for practically every conceivable need of the station. The machine shop is a separate building and is constructed in the same manner as the station itself, a structural steel frame with corrugated asbestos covering.

An auxiliary building, of similar construction, contains, besides the two 62½-kva. gas-driven electric alternators and their component switch boards, voltage regulators, transformers, etc., the two gas-engine driven compressors used for starting air, the two motor generator sets used for keeping the ignition batteries charged and also four 15-hp. 3-phase electric motors driving turbines used in circulating the cooling water.

The water supply is obtained from either one of two wells, being lifted by an electric turbo pump and passed through a zeolite treater and into either of the two elevated storage tanks. A 50,000-gal. storage standpipe is used for the compressors and a smaller storage standpipe to supply the houses with water for drinking and other domestic uses. The large tank is connected in such a way that it normally floats on the circulating line to the compressors but the water in it can be used for cooling in case of failure of both circulating pumps or in case of fire.

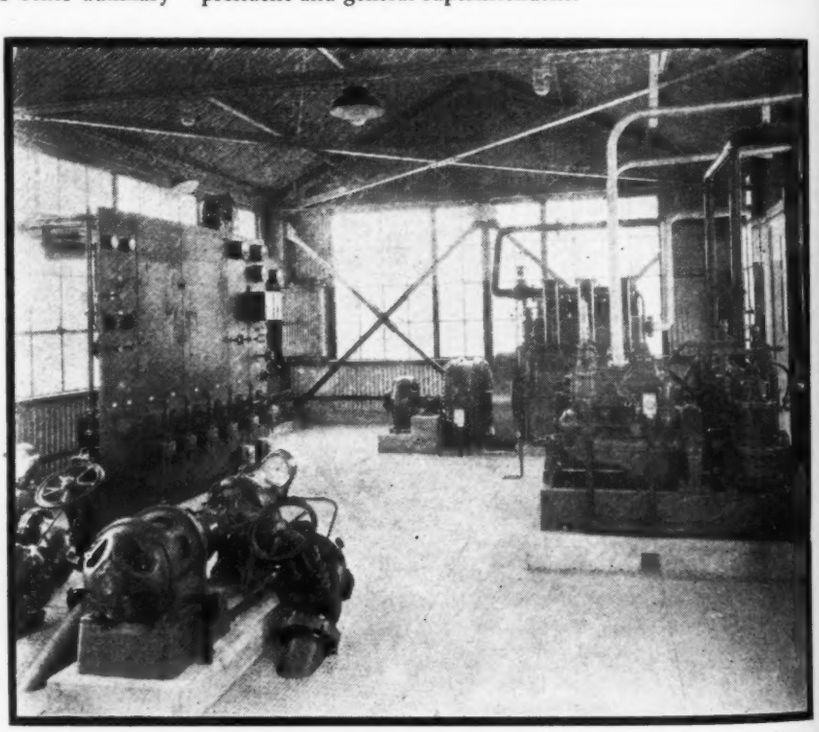
The warehouses are used for the storage of materials and supplies. In conjunction with the warehouse at each station a garage and repair shop for cars and trucks is maintained.

The isolated sites of the station placed another problem before the officials of the company, but, according to A. L. Forbes, vice president and general superintendent, this problem, caring for the employes, has been solved to the satisfaction of all concerned.

Living quarters were required for the operators of the stations. In constructing such quarters the company "went all the way" and turned out residences that would do credit to any city. Every convenience available to a city resident was included and the grounds have been landscaped to relieve the barren monotony of a mountain or desert location.

As a result the engineer in charge of each station has little difficulty in obtaining not only efficient employes but also a maximum of efficient co-operation from them.

Officials of the Western Gas Company who are responsible for the construction and maintenance plans of the four compressor stations are Paul Kayser, president; A. G. Frost, vice president and general manager, and A. L. Forbes, Jr., vice president and general superintendent.

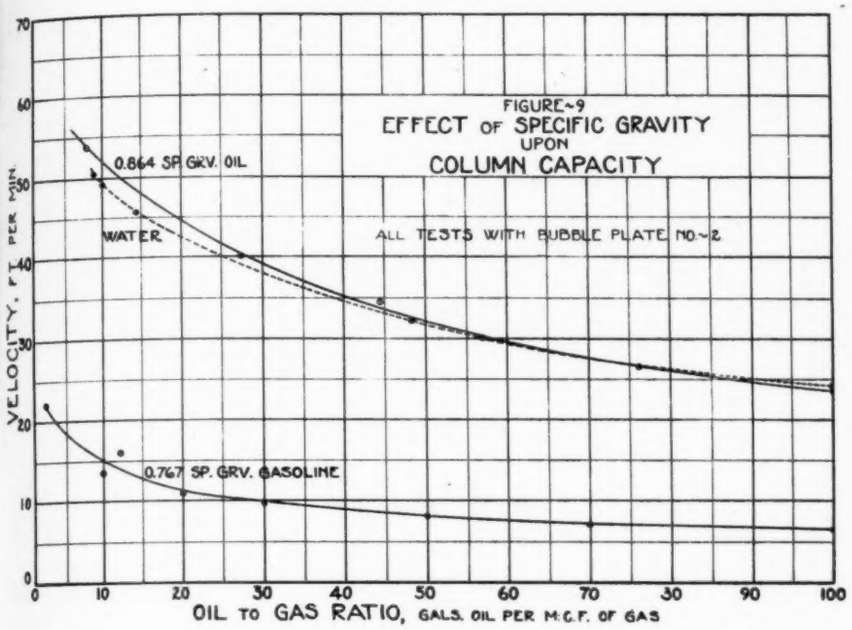


Interior of auxiliary building

Notes on Absorber Design

By F. L. KALLAM
Industrial Engineers, Inc.,
Los Angeles, California

Article 2



FREQUENTLY it is necessary to change the operating conditions for an absorber, as for example, a change in gravity of the absorbent employed. Such a move allows for conjectures as to the influence of the new oil upon tower capacity. A few tests were made to determine this effect.

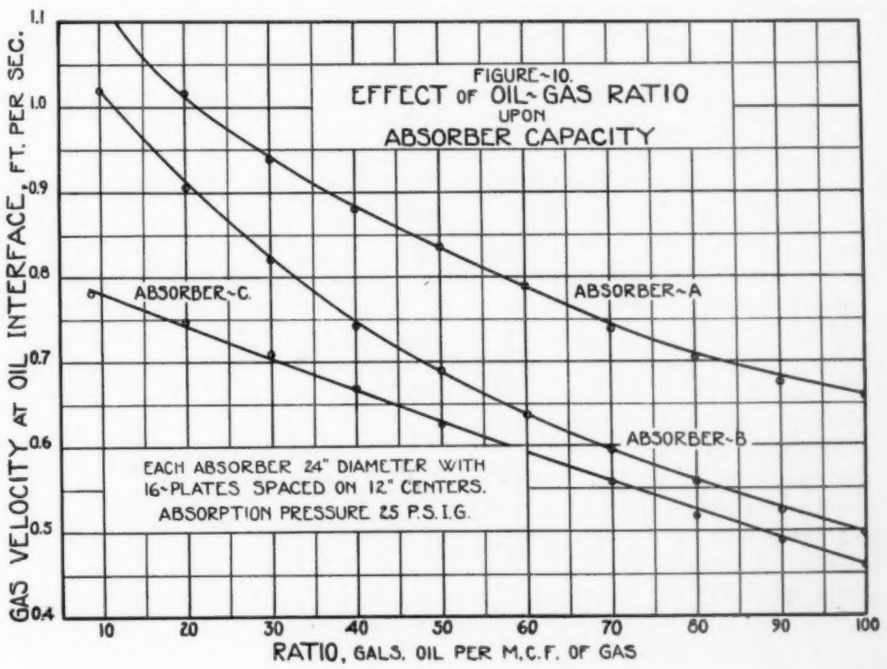
The one variable in these tests was the specific gravity of the liquid, and the results, using water, oil, and gasoline are given in Fig. 9. The comparison for the three cases are shown by plotting the maximum oil to gas ratio allowable against the vapor velocity through the tower. All liquids and air were used at a temperature of 80 deg. fahrenheit.

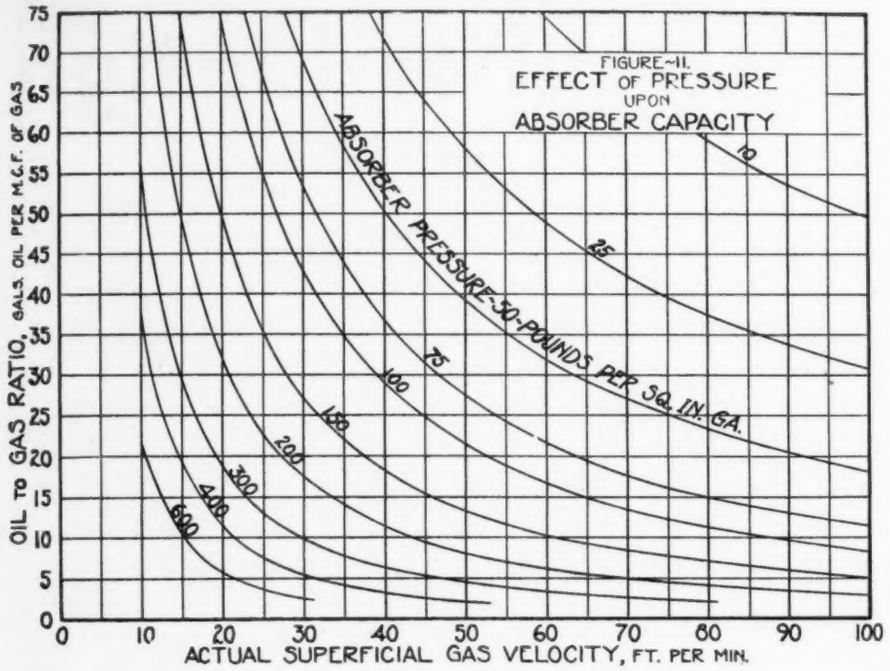
An inspection of the results of these tests shows that the tower capacity is greatly reduced when operating with gasoline. On the other hand, the capacity using oil is somewhat greater, especially at the lower oil to gas ratios, than when operating with water as the absorbent. There is, therefore, no apparent relationship between the specific gravity of the absorbent used and the tower throughput. Rather, the results obtained suggest that as the surface tension of the absorbent increases, the tower capacity also increases. The average change in this characteristic for a commercial absorbent is of such small magnitude that it is without influence upon the tower capacity.

Effect of Oil to Gas Ratio Upon Tower Capacity

The maximum gas rate at any one pressure in an absorber is entirely dependent upon the oil rate, a fact that is often overlooked. This effect on three different types of towers is shown graphically in Fig. 10. Here the actual gas velocities through the free area of the towers are plotted as ordinates and the corresponding oil to gas ratios as abscissas. The plot is self-explanatory, each curve representing a tower differing from the others only in the design of bubble cap and downspout. In obtaining these data, complete testing facilities were available, including special residue gas scrubbers. These permitted the immediate detection of oil being carried from the towers by the gas.

The points determining the position and shape of the curves were taken so that the oil to gas ratios were maximum for any given gas velocity through the towers. Increasing the ratios beyond these values resulted in pronounced oil misting and carry-over from plate to plate. The curves, however, should not be used as a basis for predicting performance in other towers, for each tower of specific design will have an individual curve depending upon its various design characteristics. These





will be governed in part by the factors already discussed entering into plate design.

Effect of Pressure Upon Tower Capacity

The pressure under which an absorber is operated has a decided influence upon the amount of gas that can be processed satisfactorily. In order to determine the effect of pressure variation, full-scale tests were made upon a 48-in. diameter tower equipped with 16 bubble plates spaced on 18-in. centers. Operations were carried out over a pressure range from 5 to 500 lb. per sq. in. gauge and oil to gas ratios from 3 to 75 gal. of oil per thousand cu. ft. of gas treated. For each oil to gas ratio and pressure the actual superficial gas velocity was determined. This determination was based upon the amount of absorption oil carried from the tower by the gas, and in every case, the gas rate was adjusted so that this loss was less than that which would be acceptable in efficient commercial operation.

The data secured from these test runs have been plotted and are as given in Fig. 11. These curves show that with increased pressure the actual superficial gas velocity must be reduced if oil carryover is to be prevented. This assumes a constant oil to gas ratio for the pressure considered. To maintain a constant gas velocity at numerous pressures it thus becomes necessary to reduce the oil to gas ratio as the pressures are increased. As operating pressures are increased the gas density increases, and at the higher pressures, it actually approaches the density of the absorbent oil. The problem of separating out the oil from the gas under such conditions is difficult, and in a given absorber, can only be accomplished by reducing the oil per unit of gas.

Effect of Plate-Spacing Upon Absorber Capacity

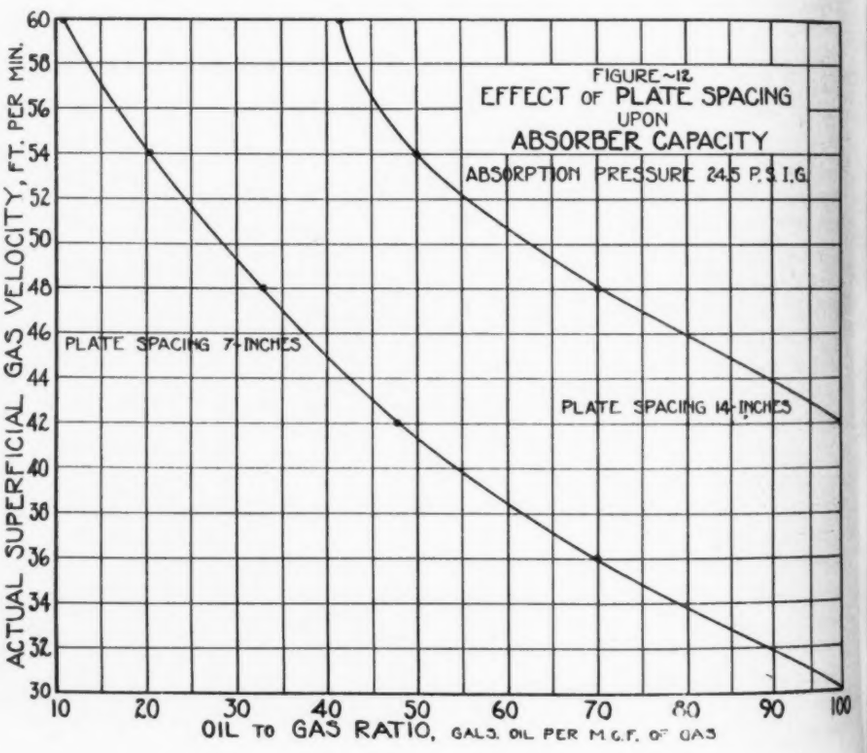
The effect of bubble plate spacing upon absorber capacity is shown graphically in Fig. 12. Although these data are by no means complete, it does depict the results obtained with a 24-in. diameter tower operated under average commercial conditions of 25-lb. pressure. Two spacings of plates were employed, one at 7 in. and one at 14 in.; in each instance, the bubble plates were identical.

For a given oil to gas ratio it is apparent that doubling the plate-spacing, under the test conditions, permitted the employment of about 12 ft. per min. greater superficial gas velocity. Or, for a given gas velocity, the 14-in. plate arrangement permitted doubling the oil to gas ratio. The conclusion from this test is that far more consideration should be given to greater plate-spacing because of the greater capacity that it gives to an absorber. Although the greater spacing calls for a somewhat higher tower, the general overall economics will be found to be in favor of this type of construction.

Effect of Oil to Gas Ratio on Pressure Drop

In the average commercial absorber installation, as made in the oil industry, pressure drop has never been of vital importance. Pressure drops of the order of two to four lb. have been acceptable. In rare instances, however, loss in pressure through the absorber has caused some concern.

Some data have been obtained upon the pressure drop phenomena that may prove of interest. This information was obtained from a test absorber operated with an actual gas velocity of 1.1 ft. per sec. at an absorption pressure of



MORE POWER IN SAME SPACE

TYPE-11 COOPER-BESSEMER

THE Cooper-Bessemer Type-11, two-cycle, gas engine driven compressor offers more power and greater compressor capacity in the same space. It is similar in design to the famous Type-10, except it has 17" diameter power cylinders and correspondingly greater power. Type 11's have now been operating for months in the field and are thoroughly tested. This larger compressor is not intended to replace the Type-10, but is available for jobs where greater capacity is required.

Field-Proved Features of Types 10 and 11

Power cylinders water jacketed full length; positive flow through exhaust bridges.

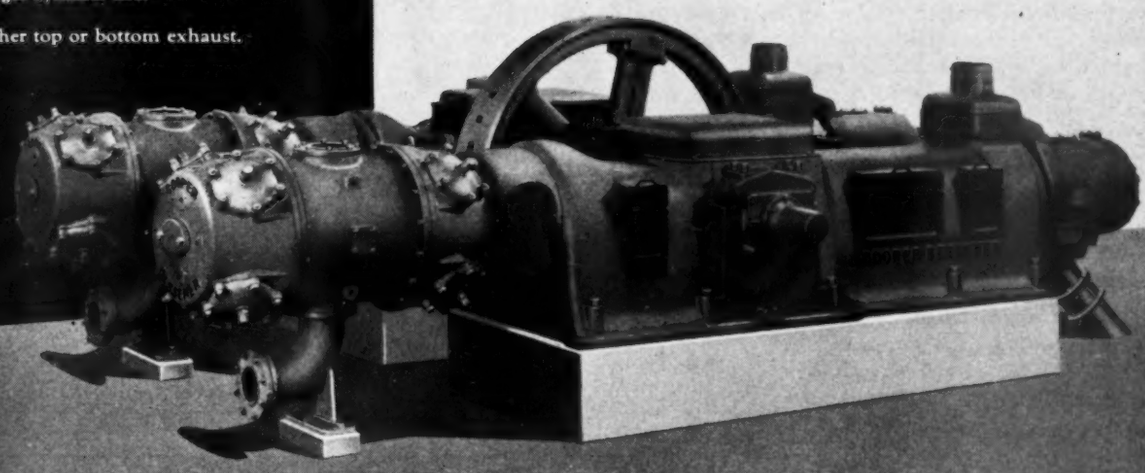
Cylinder heads and power cylinders easily cleaned of sediment and scale.

Cast alloy steel cylinder heads eliminate breakage.

Cylinders force-feed lubricated, completely around bore.

Size and location of inlet and exhaust ports give greater power and longer cylinder life.

Either top or bottom exhaust.



THE COOPER-BESSEMER CORPORATION

Mt. Vernon, Ohio — PLANTS — Grove City, Pennsylvania

201 East 1st Street, Tulsa, Oklahoma
1314 Magnolia Building, Dallas, Texas
25 West 43rd Street, New York City
225 Crockett Street, Shreveport, La.
505 Esperson Building, Houston, Texas

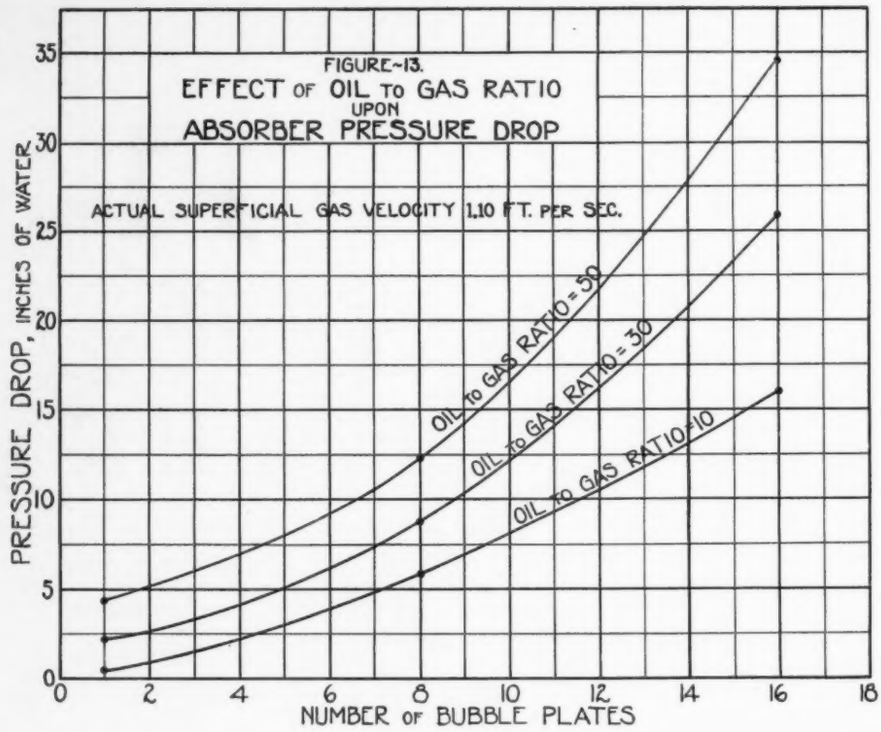


FIGURE-13.
EFFECT OF OIL TO GAS RATIO
UPON
ABSORBER PRESSURE DROP
ACTUAL SUPERFICIAL GAS VELOCITY 1.10 FT. PER SEC.
OIL TO GAS RATIO = 50
OIL TO GAS RATIO = 30
OIL TO GAS RATIO = 10
PRESSURE DROP, INCHES OF WATER
NUMBER OF BUBBLE PLATES

25 lb. per sq. in. gauge. In the tests all factors, such as plate-spacing, gas rate, and temperatures were held constant. The oil to gas ratio was the only variable, and the resulting pressure drops for each of these rates were taken at three points within the tower. The data so obtained are presented in Fig. 13, which represents a plot of the pressure drop across the various plates for each of the three oil to gas ratios used.

In analyzing these curves the points already discussed pertaining to the effect of submergence and weir fall-distance must not be disregarded. Thus by increasing the oil to gas ratio from 10 to 30, the pressure drop through the 16-plate absorber was increased ten inches of water pressure. When the 50-ratio was used, the pressure drop increased 24 inches of water pressure. This illustrates again the importance of the operating oil to gas ratio in absorber design, and where pressure drop must be closely maintained, its effect cannot be disregarded.

Effect of the Number of Plates Upon Absorber Performance

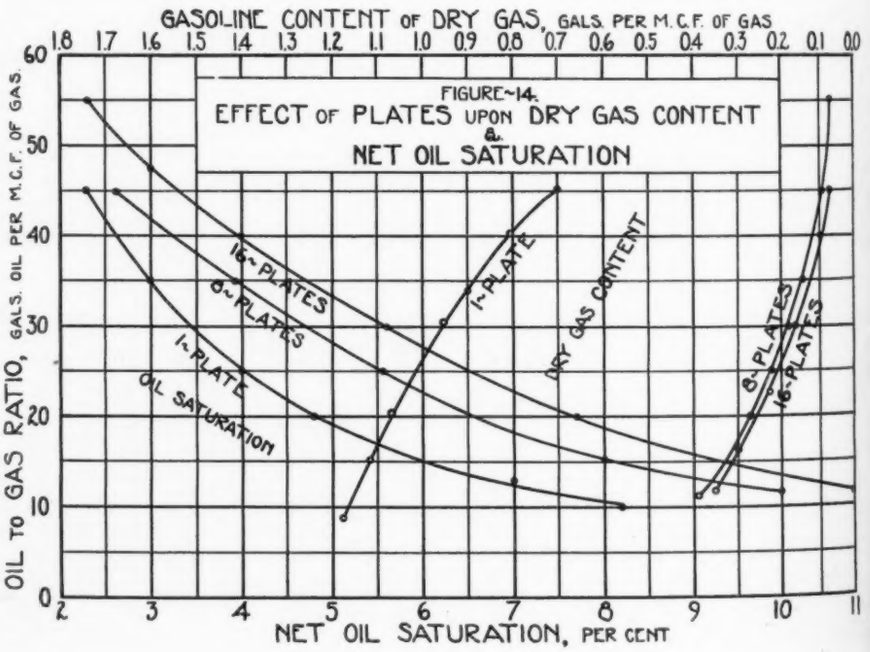
In connection with the test work forming the basis of this paper, some interesting information was obtained regarding the effect of the number of bubble plates upon absorber operation. Such data resulted from the operation of the 24-in. test absorber with one plate, eight plates, and 16 plates. All operating conditions were held constant except the number of plates, and consequently, the plate-spacing. When using the tower with 16 plates, the spacing was seven inches; with eight plates, 14 inches; and in the case of the single plate, it was located 121 inches below the top of the absorber.

For the three conditions of plates, the tower was operated over a 24-hour period, continuous samples of oil and gas being taken over this period. Absorption pressure averaged 24.5 lb. per sq. in. gauge for each test, while the absorption oil and gas temperatures were 88 deg. fahrenheit. The wet gas analyzed about 1.8 gal. per thousand cu. ft. of gas treated, this value being based on butanes and heavier. Lean oil averaged a gasoline saturation of approximately 1.14 per cent.

The results of these tests are graphically shown in Fig. 14 by plotting net oil saturation and dry gas gasoline content against the oil to gas ratio used for each of the three bubble rate conditions. From the standpoint of gas-stripping under the test conditions, little benefit was derived by the use of 16 plates as against the use of eight plates. It is also interesting to note the results obtained in this respect by the use of a single bubble plate.

When considering the degree to which the lean oil was saturated with the gasoline fractions from the gas, the results from the single plate operation are surprising. It is also evident that additional plates increase the saturation per cent in decreasing increments. The use of the single plate has of course no commercial significance, but it does afford the means of observing the effect of the maximum possible driving force between the gas and oil. With single plate operation the richest gas contacts the leanest oil, an ideal condition that is not approached in actual practice.

General conclusions from these plate tests might be that 16 plates in an absorber are ample for the average full-scale operation. This is of course only true when no regard is given the relative selective absorption of the various individual hydro-carbon fractions.



Low Capacity, High-Head Centrifugal Pumps For Refinery Uses

By
W. R. LAYNE

THE widespread adoption of the various so-called solvent processes in oil refining has sharply stimulated the demand for small capacity, high-head pumps. These conditions, in the past, have been the most difficult to meet with centrifugal pumps, and it has become almost axiomatic in extreme cases to disregard them for such services.

In the past, oversized pumps, throttled, have been used for these conditions, but usually the total horsepower required was small so that efficiency was not of primary importance. However, with the very high heads now required, the total horsepower for even very small capacities is sufficiently large to make good efficiencies more than desirable.

To meet these conditions, there is now on the market a line of centrifugal pumps designed for very low capacities, say, in the range of 10 or 20 gal. up to about 150 gal. per min. against heads up to 2000 or 3000 ft. in single pumps, and when working in series up to as high as 10,000-ft. heads.

These pumps are multi-stage pumps, employing impellers of small diameters, and differ from the conventional type of multi-stage centrifugal pumps in that there are a great many impellers employed in one pump, and they operate in a vertical position and at rotative speeds in the neighborhood of 3600 r.p.m.

In practice in the past, when designing centrifugal pumps for high speeds, it has been usual to attain such high heads by increasing the impeller diameters, and by increasing the rotative speeds. Therefore, it would seem obvious greatly to increase the impeller diameter in order to minimize the number of stages and greatly to increase the speed. In order to design for small capacities, the conventional practice would be to narrow the impeller. If the diameter and speed of a given impeller each be doubled, the resulting head would be, theoretically, 16 times the head of the original runner.

However, there are certain practical limitations on speeds and heads and impeller widths that make it impossible to attain very small capacities and very high heads at commercial efficiencies by merely increasing runner diameter and speed and sticking to the general practice of limiting the number of stages to six or eight, as at present in most types of multi-stage, horizontal, centrifugal pumps.

Speeds are limited commercially in electric motors to a maximum of 3600 r.p.m., and since it is most desirable to direct-connect centrifugal pumps and electric motors, this speed is in general the maximum that may be employed by the designer in his struggle to attain the ever-increasing height of head demanded by the industry. However, there is no good hydraulic or mechanical reason why much higher speeds should not be employed in operating centrifugal pumps to attain very extreme values in low capacities and high heads, say, speeds of the order of 7000 or 8000 r.p.m.

With the limited speed of 3600 r.p.m., the heads obtainable in a single impeller are limited to the maximum diameters of impeller that can be safely operated without bursting, and to maximum diameters taking into consideration the matter of disc friction and other losses in the pump due to increasing diameters.

Now that these tremendously high heads are acquired for quan-

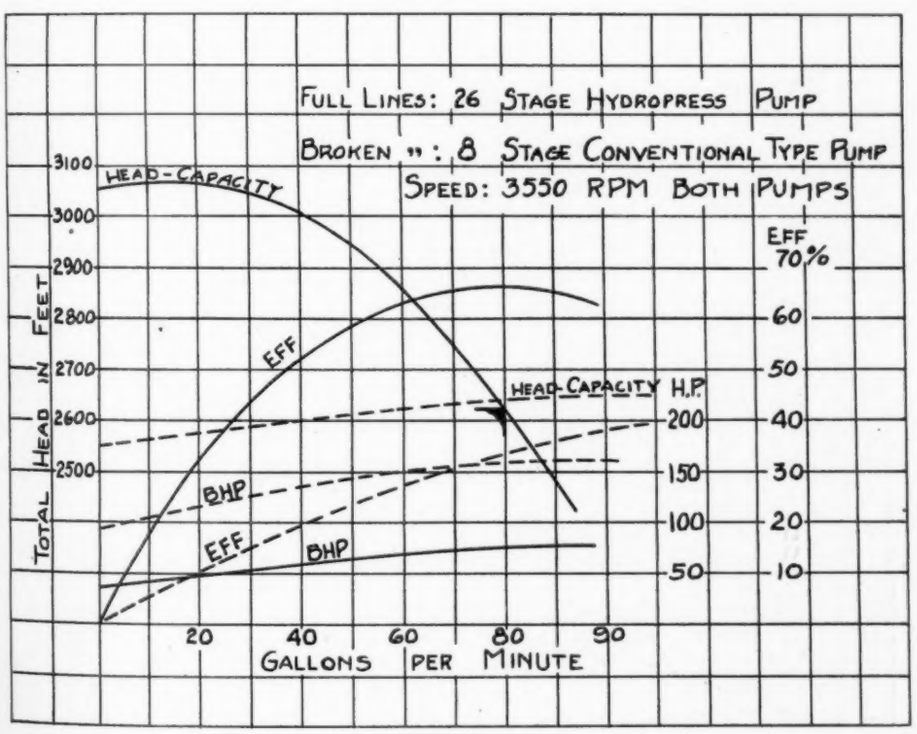


Fig. 1

tities as low as 25 gal. per min., which result in very considerable horsepower requirements, designers must study every factor having a bearing on efficiency. These small capacities, dealing with fairly modest impeller diameters, say, 10-in. or 12-in., which might be practical for 3600 r.p.m., would dictate a very narrow impeller, say of the order of $\frac{1}{16}$ in. or less. Such exceedingly narrow impellers are impractical for several reasons, such as the difficulty of manufacture, liability of becoming clogged, but worst of all for excessive disc friction losses and pure friction losses, which greatly impair the overall efficiency of the pump.

By making the impellers of very small diameter, the width may be made great enough, even for quantities as low as five or ten gal. per min., to permit easy and perfect casting, the danger of clogging is minimized and the disc friction so reduced that efficiencies are realized that are comparable with pumps of 200 or 300 gal. per min. The high heads required are attained by utilizing a multiplicity of stages, the pumps being arranged vertically to avoid shaft deflection that would result with horizontal pumps.

The rotating elements are carefully balanced, and although operating at 3600 r.p.m. and utilizing many stages, these pumps do not need to be bolted to the foundation, but merely may stand on the floor and operate. They operate so quietly that the casual observer would in many cases not be able to detect their motion.

The accompanying curves (Fig. 1) show the relative performance of the new high-speed, small diameter, multi-stage pump, as compared with the older type of large diameter, over-sized pump usually offered but seldom accepted for such rating.

The curves shown in full lines are for a 26-stage Hydropress pump, rated at 80 gal. per min. and 2600 ft. of head, with an efficiency of 66 per cent. The broken lines show the performance of an 8-stage horizontal conventional type pump, which would normally be rated at about 400 gal. per min. Therefore, at the rating of 80 gal. per min. and 2600 speed, the efficiency of the 8-stage pump is only 33 per cent. Therefore, the saving in horsepower by the use of the Hydropress pump is the difference between 159 and 74 or 85 horsepower.

These pumps are now available for hot and cold services, in capacities from 10 to 150 gal. per min., up to heads of 2600 ft. in a single pump, or by running several pumps in series up to 10,000 feet.

The accompanying table shows some of the ratings now commercially available for both hot and cold oil services, car washing, accumulator service at steel mills, gland-sealing in high-pressure boiler feeders, for washing scale from steel in rolling mills, cleaning the interior of copper tubing, etc.

The following cut shows a typical example of these pumps. Fig. 2 shows rotating element, inner volute case and outer barrel of 10-stage pump.

TABULATION OF RATINGS

Gallons per Minute	Head		No. of Stages	Efficiency %
	Ft.	Lb./sq. in.		
10	2700	1170	54	47
20	2400	1060	54	60
40	3000	1300	35	60
60	2400	1060	26	61
80	2600	1135	26	65
100	3000	1300	17	65
150	3000	1300	17	65

These pumps employ the well-known method of double-case construction. The inner or volute case is a relatively light casting of proper shape for correct hydraulic considerations, enclosed in a simple cylindrical outer case. The inner case is longitudinally split, the joint being a ground metal-to-metal fit, without gasket. This design allows easy assembly, the rotating element being accessible as a complete unit. The inner case is subjected to compression stresses only; hence, the bolting is simple and light.

The outer case is subjected to the tension stresses of the operating pressure; hence, the simple cylindrical shape is well fitted for the service. It is usually made of seamless steel tubing with welded flange and head, but for extremely high heads steel forgings are used.

Only one stuffing box is used, and this is subjected to suction pressure only.

No foundations are required for these pumps, as they are light in weight and run without vibration. In some cases they are supported on structural steel beams; in others they merely stand on the pump house floor, and sometimes they are thrust into a hole in the floor, with the nozzles and motor head standing just above the floor. It is obvious that the required floor space is very small.

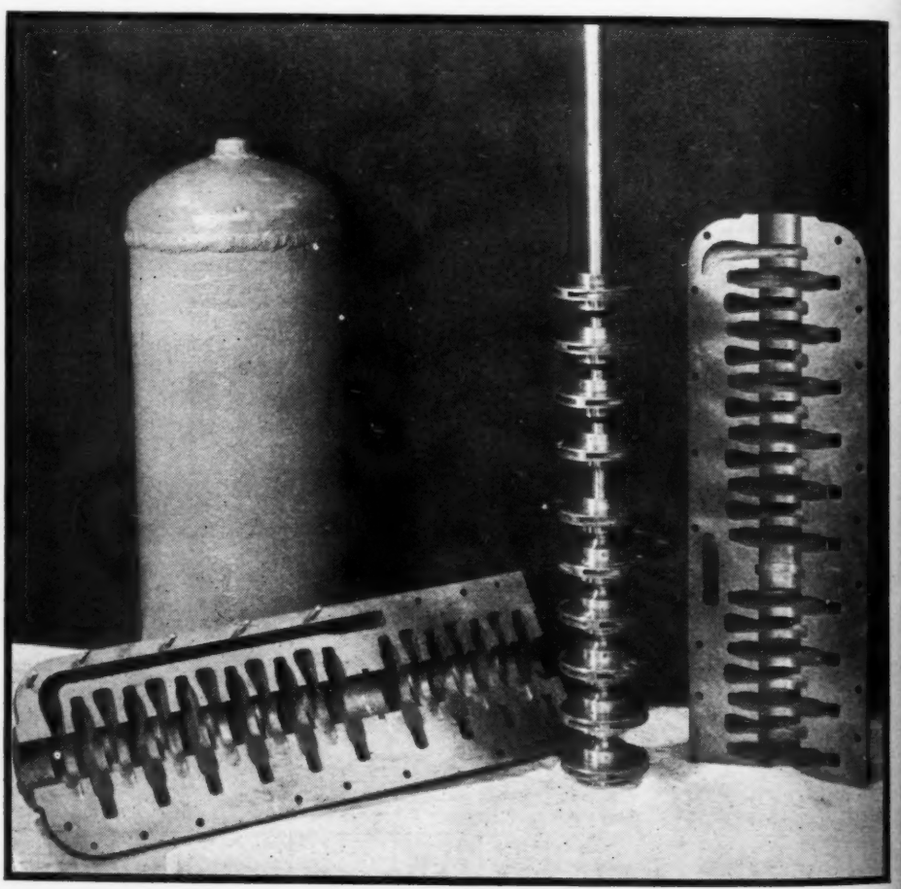
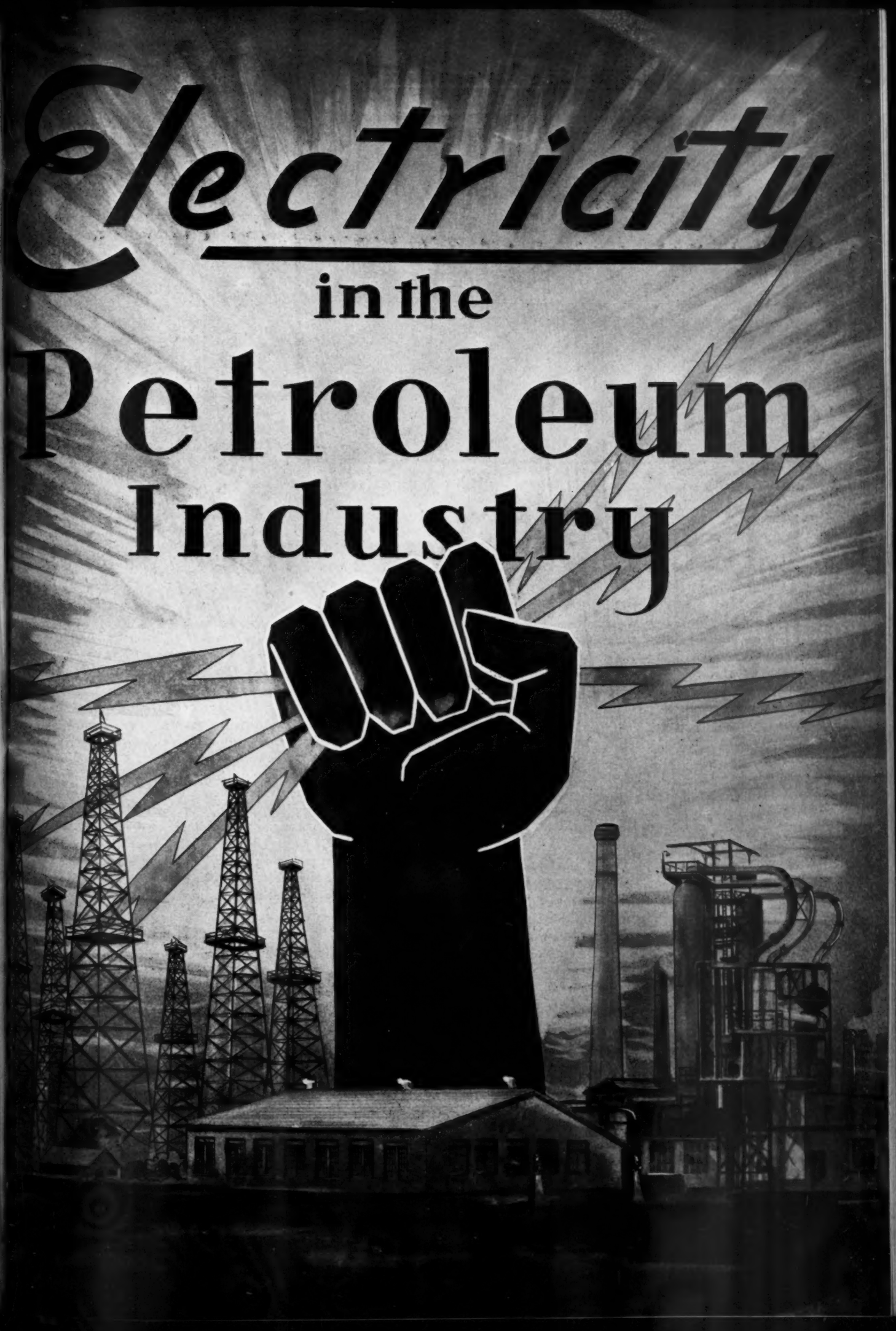
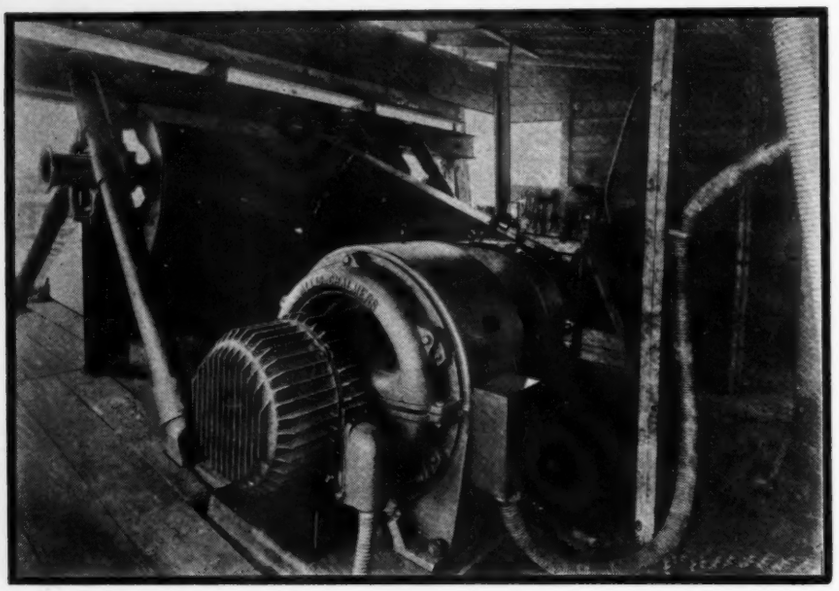


Fig. 2


Electricity
in the
Petroleum
Industry



250/85-hp. protected type drilling motor operating drawworks on well in the Oklahoma City field

Electric Power in Drilling

ELECTRICAL energy has been associated in some manner with the oil industry from the days of the pioneer to the present time. The first application was the telegraph and a little later the telephone came into use. In a sense, the first strictly power applications were of an auxiliary nature and included such work as providing electric ignition for gas engines used for pumping, igniting explosives used for shooting wells and lighting such properties as were near electric plants or service lines. The introduction of a reliable rig lighter operated by a small steam turbine met with universal favor and it was not long before practically all drilling rigs were equipped with them. Up to this period electric motors had been used in the oil industry only to a limited extent.

Pumping

The first major application of electric power in the development and the production branches other than for lighting was for pumping. The initial installations were in fields situated near regions traversed by a-c. electric power lines so a-c. motors were used on the first drives. As soon as the relative advantages, reliability and economy of electric pumping had been established a number of generating plants were built in isolated fields and the use of electric power became widespread.

Evolution of the Double-Speed Motor

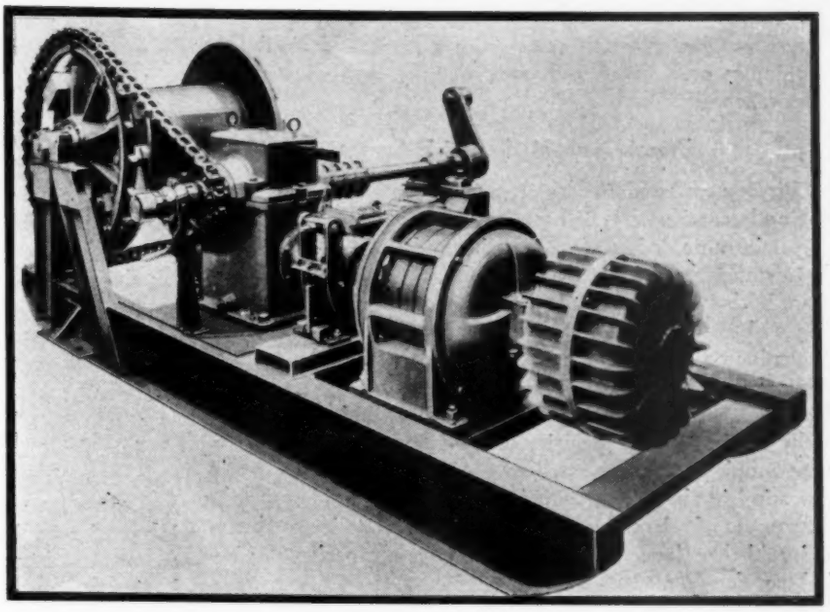
The first motors to be used on pumping rigs had been designed for other work and, as one would expect, some difficulties were encountered, chief among which was that resulting from the prevailing idea, fostered by the long-established custom among operators, that each well should be equipped primarily for drilling and that the work of pumping is of secondary importance. It is well known that the capacity demanded for drilling, handling pipe and pulling rods is quite different from that required to pump a well and the speed at which the work is done is much the higher. To meet this situation the electrical manufacturers designed the double-speed slip ring motor that has a high rating at 1200 r.p.m. for drilling and pulling and a low rating at one-half this speed for pumping. To insure the motors against the conventional abuse imposed on oil field equipment they were greatly underrated. It is to be expected that such a motor cannot be very efficient under either load condition; its power factor will be low and its first cost relatively high, but since at the time, all the oil one could pump from a well was in demand at a fair price, apparently few people gave much though to the item of efficiency and to the effect of such a motor on the future use of electricity when competing with other forms of energy. These motors have had a wide application and are still in favor for isolated locations where both pumping and pulling work is to be done or where the loads are so heavy that they may be operated at the higher rating.

The Squirrel Cage Motor

As conditions in the oil industry changed more thought was given to the problem of efficient pumping and squirrel cage motors in assorted sizes for operating wells of widely different production and depth were introduced. Some operators adhered to the idea of pumping and pulling wells with the same motor. In order to accomplish this the single-speed, double-rated, Star-Delta squirrel cage and slip ring motors were introduced. Motors were installed, when connected in Star, had ample capacity for pumping, and when pulling work was to be done, were connected in Delta. The efficiency of such a motor at the Star rating is slightly better than that of a single-rated motor of the same capacity.

Present Practice

The tendency at the present time is to use squirrel cage motors of ample capacity for pumping duty only and to resort



G-E automatic weight control for oil-well drilling

By
W. C. LANE
Electrical Engineer

g and Production of Petroleum

to portable pulling equipment. Where power is procured from a system having an ample capacity it has been found that motor-operated winches mounted on a truck are very satisfactory. At other times tractors or trucks with a power take-off are used. It may be said that the Star-Delta system for pumping and pulling is still favored by some operators.

The triple-rated motor, which differs from the Star-Delta motor only in that it has three additional leads brought out from the stator winding, is being received with favor by some operators. The object in using it is to have a high rating to use in case a well starts to make large quantities of water, or in case that proration is lifted or potentials are to be established. Since the idea is based on the old principle of overmotoring all wells from the fear that some may be undermotored, it should be approached cautiously. It appears to be sound from the standpoint of the small operator devoid of an engineering organization, but stocks of oversized used motors in the warehouses of major operators are never conducive to the sale of electric power and equipment.

As to the method of applying motors to pumping wells, the rig front with countershaft and either flat-belt or V-belt drive is still in general use but the tendency is to use individual pumping gear units. Motors are coupled to the high-speed shaft of the units or connected to it by a V-belt drive. The latter method seems to be in the more general favor by reason of the wide flexibility in speed.

In a number of light pumping fields marked economies have been introduced by the use of slow-speed pumping with small motors. Some form of a speed reducer, which may be a light reduction gear or a series of countershafts with chains or V-belts, is used in conjunction with the old equipment on the well. Perhaps the latest form of a drive of this nature is the gear-motor, which is a motor and a reduction gear enclosed in the same housing. Such a unit belted to a pulley mounted on the shaft extension of an ancient double-speed motor will often pay for itself out of the saving in the power bill in a year's time.

Central Pumping Power

Central pumping powers, both bandwheel and geared, are operated by electric motors. Both slip ring and squirrel cage motors are used on this work, but the former is in more general favor by reason of the ease with which it will start a load. A high slip, squirrel cage motor in combination with a flywheel has been found to be both economical and effective on installations that include many part-time pumping wells that are hooked off and on at irregular intervals and thus throw the power out of balance. Where double-speed motors are used on powers it is obvious that such should be operated on the high-speed connection with all the control resistance cut out if a reasonably high efficiency is to be obtained.

Small Electric Plant

Much interest has been aroused as a result of the reported economies obtained by pumping leases with electric power produced by a small generator driven by a gas, distillate or Diesel engine. Such an installation can be operated as a unit by the regular pumpers and will perform efficiently all the functions of a bandwheel or geared central power in addition to lighting the lease and making possible the use of many domestic comforts in the homes of the lease residents. It has been demonstrated that a modern internal combustion engine and a generating unit will operate for long periods of time with no other attention than that given by an intelligent pumper and an occasional inspection by an engineer. A number of these plants have been installed in the Mid-Continent area during recent months. Electric time clocks have been perfected so that it is possible to start and stop the wells at any convenient intervals. This not only enables the operator to avoid starting more than one motor at a time from a plant

of limited capacity, but it also enables him to operate a larger number of small wells from a plant and obtain the maximum production from each without disturbing any of the other wells.

Direct-Connected Electric Pumps

Direct-connected electric pumps of both the reciprocating and centrifugal type have been developed. The former is as yet in more or less of an experimental stage but the latter has demonstrated its reliability and usefulness beyond question. Both types are placed on the bottom of a string of tubing and are operated by electric current transmitted by a 3-conductor cable, which passes down through the annular space between the tubing and the well casing. It appears that the centrifugal pump can be used economically only on wells making a large quantity of fluid. Several pumps of this type coupled to motors rated at 97½ hp., 3600 r.p.m. are in operation in the Oklahoma City field and are said to be the forerunner of a large number to be used by a major producer. It is said that these particular pumps have a capacity of 1000 bbl. per day on a 6300-ft. lift.

Electric Heating

It sometimes happens that during the life of a company-owned power plant there are periods during which the load factor on the plant is low and the fuel used is a waste product. At such a time the actual cost of producing additional electrical energy is nominal. Flow line, tank and dog house heaters have been developed that enable the operator to use such surplus energy very effectively. Bottom-hole heaters for the reduction of paraffin have been found to have much merit on certain types of wells. It appears that there is a possibility of obtaining much additional production from the stripper fields by the use of portable heaters if these are arranged to be run in and out on a cable quickly.

Power Rates for Pumping

Fortunately the rate makers of the electric power companies are being persuaded to consider the pumping problem under existing conditions in the oil industry from the producer's point of view. More attractive rates are being established with fewer restrictions and in the flush fields that are now approaching the pumping stage it appears there will be a substantial increase in the use of electrically-operated pumping equipment. The practice of basing the demand charge on the daily pumping load rather than on the load developed during the 24-hr. period while a potential test is in progress should, if at all possible, be made universal.

Drilling With Cable Tools

The first serious attempts to drill with electric motors were made about 25 years ago. As is the usual custom in pioneering in any line, motors and controls that were designed for other service were used and it appears from the reports that the drilling crews were not very enthusiastic about using the new kind of power. From what we know now it appears that the motors were too small, did not have enough torque in pulling out and the controls did not provide for as fine a speed adjustment as is needed to make the tools drop as they should. It was not long before manufacturers coöperating with the oil company engineers determined the capacity of the motors required, the characteristics they should have and the arrangement of the control grids necessary to enable the driller to obtain the proper motion.

Methods Developed

Two methods for getting the speed variation were developed—the single motor and the twin motor. In the first method a single- or a double-speed motor is used and depends on the principle of providing enough main and auxiliary resistance steps in the control to give the desired speed flexibility. The twin-motor method as its name implies uses two double-speed motors belted to a common jack shaft. The controls used are less elaborate and fine speed adjustments are obtained by increasing or decreasing the sped of one motor without disturbing the setting of the controller of the other. Little improvement has been made on the two systems during the last ten years and both methods still have their advocates.

Deep Well Cable-Tool Motor

Since drilling depths have increased there is a demand for more speed in pulling the tools, bailing and swabbing. A larger motor has been used in order to accomplish this but trouble is experienced in getting the tools to drop. For drilling a motor must be small enough to tend to shirk its load without having too much resistance in the circuit. It is suggested that light rotary motors such as the 125-hp. or 150-hp. motors in common use be arranged for Delta-Star connection—Star for drilling and Delta for hoisting.

The Small A-C. Plant in Drilling

Cable tools have been operated with few exceptions from a-c. power systems having a large capacity. The a-c. motor by nature draws a very heavy current from the line when starting a load, and while this is a so-called wattless current and does not overload the engine driving the generator it does overload the generator and causes the voltage to drop very materially. For this reason the operation of a cable-tool rig from a small portable generator driven by an internal combustion engine is not very satisfactory and the system has not been used extensively.

Ward-Leonard System for Cable Tools

The ultra modern system of cable-tool drilling is that which makes use of the Ward-Leonard system of speed control. In this system a separately excited d-c. motor is operated from a separately excited generator with series field differentially connected driven by an internal combustion engine. In drilling the rheostats are set so that the voltage of the generator decreases sharply when the tools are picked up and increase when they fall and the load drops. Since the speed of a separately excited motor is proportional to the voltage, the variation in the generator voltage causes a variation in the speed of the motor and this imparts a corresponding motion to the tools. In hoisting it is impossible to overload the engine on account of the automatic action of the differential field of the generator. The hoisting characteristics are ideal since the motor can exert its maximum torque while at rest or at any speed up to that which corresponds to the maximum load for which the series field of the generator is set. The efficiency of such an installation is high, since no rheostats are used in the main circuit to dissipate energy as in the case of an a-c. drilling motor.

Electric Rotary Drilling

About 15 years ago men associated with rotary drilling work began to give some thought to the possibilities of applying electric motors to rotary rigs. Since power-driven pumps were already in use it was evident that the major problem

was purely one of hoisting. Manufacturers had perfected a-c. motors for other work and it was a comparatively simple matter to make use of these. From the point of view of present practice the first rigs were greatly undermotored and in several cases industrial type low-torque motors were used. After a relatively short period of experimental work several methods of applying electric motors were developed.

Single Drawworks Motor

The first method to be used consisted of a separate motor on each mud pump and a third motor on the drawworks. The capacity of the first drawworks motors to be used varied from 60 to 75 horsepower. Due to the insatiable desire of contractors for larger and larger apparatus the sizes have gone through the following values: 100, 125, 150, 200 and 250 horsepower. Some motors are now in use rated at 250 hp. that have a pull out load capacity of more than 800 horsepower. These motors are arranged so that the stator winding may be connected in Star for drilling and in Delta for hoisting. Single motors may be applied through the agency of a single reduction gear or in conjunction with a more highly developed drive such as the Hydril and others of a similar nature. The capacity of the mud pumps has been increased in about the same proportion. Some of them now in use are such that they require a 250-hp. motor to operate them.

Twin-Motor Speed Reducer

A large hoisting capacity has been obtained in another way by the use of a twin-motor speed reducer. Two 125-hp. motors are geared separately to the slow-speed gear shaft. Both motors are energized while hoisting and only one while drilling; the other motor rotates during drilling operations but is disconnected from the circuit.

The Halliburton Drive

Crooked holes have always been a troublesome and expensive factor in drilling and producing oil wells. Up to the time of the introduction of the acid bottle test no one realized just how far some of the holes were deviating from the vertical. Little thought was given to the possible effect of torque and weight control on the path taken by the bit, the object of the average driller was to make the most hole in the shortest time, provided he could keep out of trouble.

The Halliburton drive was introduced with the object of feeding the bit or retrieving it, as the case may be, an amount depending on the torque on the drill pipe. Apparently the original idea was to protect the drill pipe rather than to improve the quality of the hole drilled. The drive can be used with a single-motor electric rig, with a steam engine or with an internal combustion engine.

Hild Differential Electric Drive

The Courts decided that the basic principle of the Hild drive is the same as that of the Halliburton drive. In the Hild drive the drawworks is operated through a differential gear box by two double-speed electric motors. One motor is commonly thought to do the drilling and the other to feed and retrieve the bit. As a matter of fact, both motors drill and retrieve and under certain conditions, the drilling motor may do all the work and the regulating motor may be disconnected from the circuit. The full capacity of both motors is utilized when hoisting work is to be done.

Like the Halliburton system the automatic feeding and retrieving action of the Hild is actuated by the torque on the drill pipe. The system has considerable merit when used intelligently, but the device is not able to think for itself as some operators expect it to do. The system is economical to use by reason of the fact that the drawworks is not greatly overmotored while drilling and as a result the motors are more efficient than on other drives.

General Electric Automatic Weight Control

The problem of automatic feeding from the standpoint of weight control has been attacked from a new angle and the results are said to be very satisfactory. The dead line of the cable of a rig is attached to the drum of a winch connected through the medium of a link belt and a worm gear to an electric motor. Obviously the magnitude of the thrust on the worm is proportional to the stress in the dead line. This thrust is transmitted through a combination hydraulic-air-chamber-operated system to the motor starting switch. A certain stress in the line corresponding to a given weight on the bit causes the switch to take a neutral position and the motor remains at rest. Too much stress will start the motor in one direction and too little in the opposite direction. The result of this action is to keep the weight on the bit at a fixed value or within very narrow limits.

It is evident that this device can be used on a steam or internal combustion engine type of rig as well as on an electric rig provided electrical energy is available to operate it. The power consumption is said to be very small. In an emergency it can be used as a stand-by to clear the hole.

Ward-Leonard System of Drilling

Ever since the introduction of electrical rotary drilling it has been the custom for engineers visiting an oil field for the first time to remark that it is poor practice to use a-c. for drilling. The old timer's reply has usually been a shrug and a quiet remark that oil wells are not usually drilled in the back yard of power plants where d-c. energy can be procured without encountering prohibitive line losses. Engineers have agreed from the earliest days that the Ward-Leonard system of speed control has no equal where hoisting work is to be done and exact speed regulation is needed. The application of this system was made possible when the internal combustion engine manufacturers put on the market light weight engines of sufficient capacity for driving the necessary d-c. generators. The first rigs of this nature were put in service about four years ago. They were light rigs mounted on trailers, skids or on barges and are very satisfactory when kept on work within their capacity. The generators of the largest rig put out up to this time are driven by 325-hp. 900-r.p.m. gas engines and at the time of this writing the rig is being used to drill its eighth well in a locality requiring heavy equipment. It has been demonstrated very conclusively that the application of the system to heavy work is a success. In case one wishes to operate the rig from an a-c. power line, induction or synchronous motors may be substituted for the engines and everything else left just as it is now.

Electrical energy for drilling, whether it be obtained from power lines or generated on the location as in the case of the Ward-Leonard system has been found to be both reliable and economical. The saving in the items of fuel and water represents a substantial sum, especially in fields where gas must be purchased and water is scarce. The weight of the generating units of the portable d-c. rigs can be distributed so that the transportation problem offers no unusual difficulties.

Large Volume Oil-Well Pumping With Electrical Power

By W. H. STUEVE
Oklahoma Gas and Electric Company

THE oil fields of Oklahoma have in the past 30 years witnessed an interesting and ingenious array of oil-pumping devices. These have included the old-fashioned, hand-operated pitcher pump raising oil from eight or ten feet, the engine-driven central power with its multiplicity of shackle rods stretching out in every direction to the wells, the walking beam, and the air-gas lifts.

Now, with all the flexibility and portability inherent in the usage of electrical power, comes the long, slender electric motor and centrifugal pump that is lowered thousands of feet into the earth to pump oil from the bottom of the deepest of wells. Such an oil well pumping unit is the Reda pump, which consists of a two-pole, three-phase, 3500-r.p.m. squirrel cage induction motor at the bottom of the assembly, a protector chamber just above the motor, the pump intake section above the protector, and a multistage centrifugal pump above the intake. There is a special starting valve in the discharge tubing above the pump.

Several pumping units of this type are now in operation in the deep Oklahoma City field. The 97-hp. unit used in this field has an overall length of approximately 55 ft. and a maximum outside diameter of 5⅜ inches. The motor is 21 ft. long and the pump approximately 20 ft. in length.

In use the entire assembly is suspended in the well by the discharge tubing. The three-conductor armoured cable, which transmits the power from the surface to the motor in the bottom of the well, is clamped to the discharge tubing at regular intervals.

Although the motor operates at a rated terminal voltage of 750 volts, a voltage of about 880 volts is required at the surface to provide for the voltage drop in the approximately 6500-ft. length of cable used.

For control the electrical equipment commonly used consists of an oil switch, indicating ammeter, recording ammeter, and overload relays. These are housed in a weatherproof metal cubicle located a short distance from the well. Due to the increased voltage drop in the cable on starting, no compensator is necessary.

The overall efficiency of the pump and motor ranges from 33 to 55 per cent.

A summary of the records from five wells in the Oklahoma City field, operating part time between February 1 and May 1 of this year, shows the following results:

Total operating days obtaining allowable production	136
Average bbl. of oil per pump per day	972
Total bbl. of oil pumped	123,266
Average energy in kw-hr. per bbl. of oil pumped	1,966
Average repair cost in cents per bbl. of oil pumped	.56

Each of the pumps included in the above tabulation was operating at a depth greater than 6000 feet.

Although these wells are at present operating under rather favorable conditions so far as natural well energy is concerned, maximum pumping costs can be predicted with a reasonable degree of accuracy by using the following assumptions:

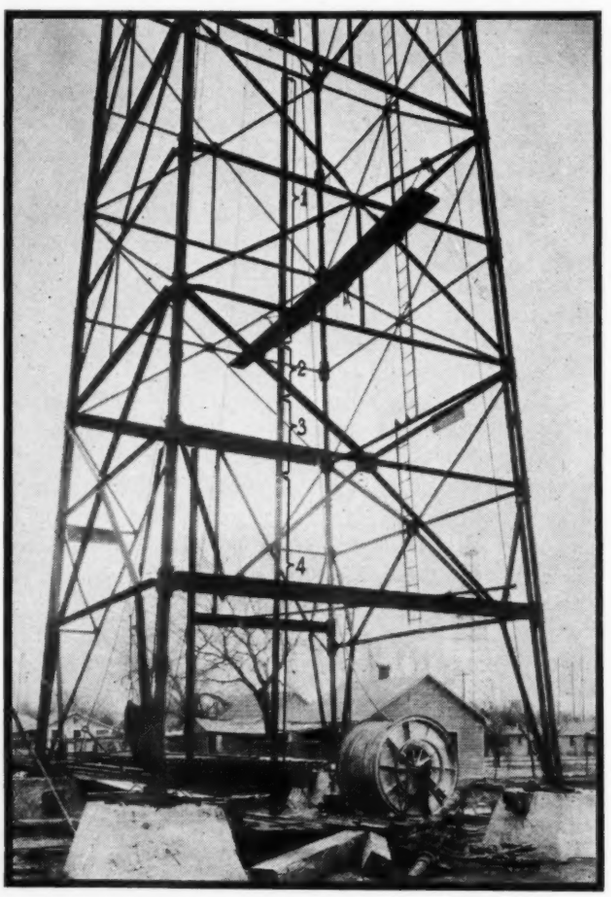
(1) Equipment cost, $10,000 per well.

(2) Average energy, 2000 kw-hr. per day.

(3) Average production, 500 bbl. per day.

(4) Repair costs, 100 per cent greater than the present average.

In terms of cost per barrel of oil produced, using the foregoing assumptions in regard to equipment cost, average energy and repair costs, we have:

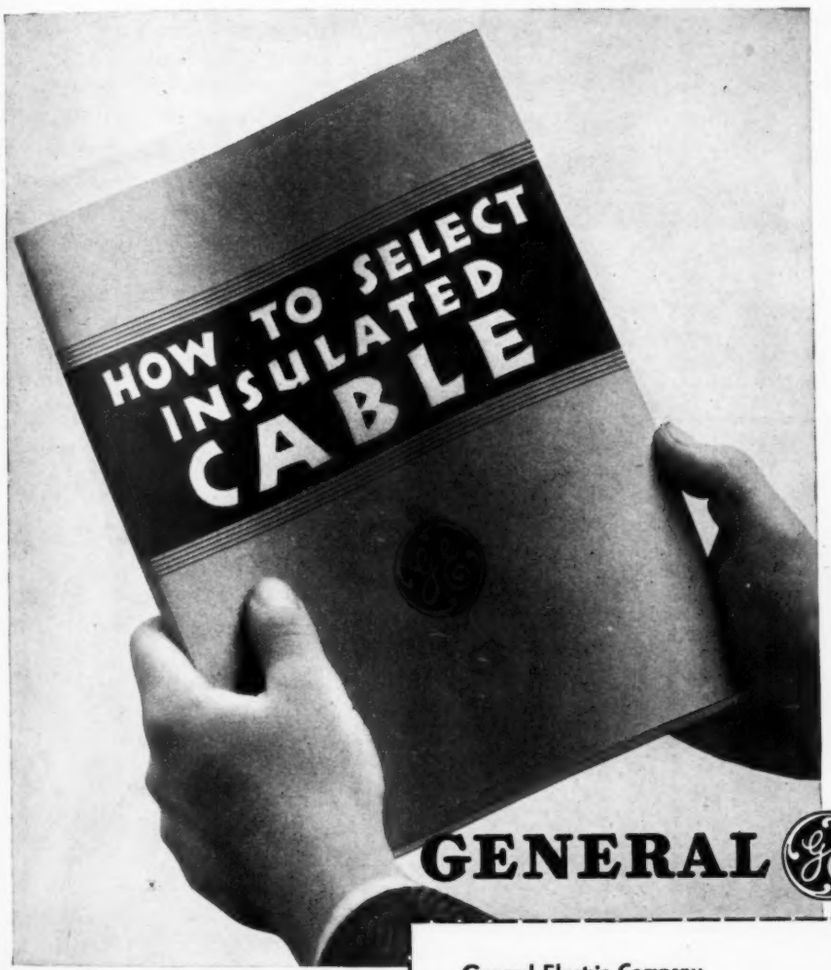


Complete Reda pump unit hanging in derrick ready for lowering into well. 1. 133-stage centrifugal pump; 2. pump intake; 3. protector; 4. motor.

NOW Complete Information on How to Select Insulated Cable

. . . A NEW SERVICE FOR CABLE USERS

IF you are interested in the selection of insulated cable for electric circuits, you will find this new 80-page reference book indispensable. It represents a new service to cable users, and puts information on selecting cable into handy, readily accessible form.



A Cable Encyclopedia

Information which has never before been conveniently accessible is now available within a single cover. Material hitherto unpublished is contained in this book. Other subject matter includes the substance of articles on cable that have appeared in technical papers — condensed, rearranged, and well indexed. Useful data have been put into easy-to-understand chart and table form.

Those Who Can Use This Book

Cable engineers, electrical engineers in industrial plants, consulting engineers, architects, contractors — all will find *How to Select Insulated Cable* of exceptional value.

This publication will be sent without charge to those requesting it. If you feel that you have need for a copy, we shall be glad to send it. Address the nearest G-E office; or General Electric, Dept. 6E-201, Schenectady, N. Y. The coupon is for your convenience.

GENERAL ELECTRIC

MAIL COUPON NOW

General Electric Company
Department 6E-201
Schenectady, N. Y.

Please send me a copy of *How to Select Insulated Cable*, GEA-1837.

Name.....

Street.....

City..... State.....

520-6

Amortization, five years	1.1c
Energy at 1c per kw-hr.	4.0
Repairs	2.0
Total	7.1c

All these figures are based on production from wells of 6000- to 6500-ft. depth.

Other sizes of units are also made and are in use in shallower wells. A study of operations in various fields where 30 odd wells have been operating for a total of 7750 days, shows the following:

Gross fluid pumped per day, 700 to 5000 bbl.

Oil ratios, 2% to 100%.

Average percentage of water, 85%.

Well depths, 2000 to 4500 ft.

Working levels, 500 to 3000 ft.

Average working level, 2000 ft.

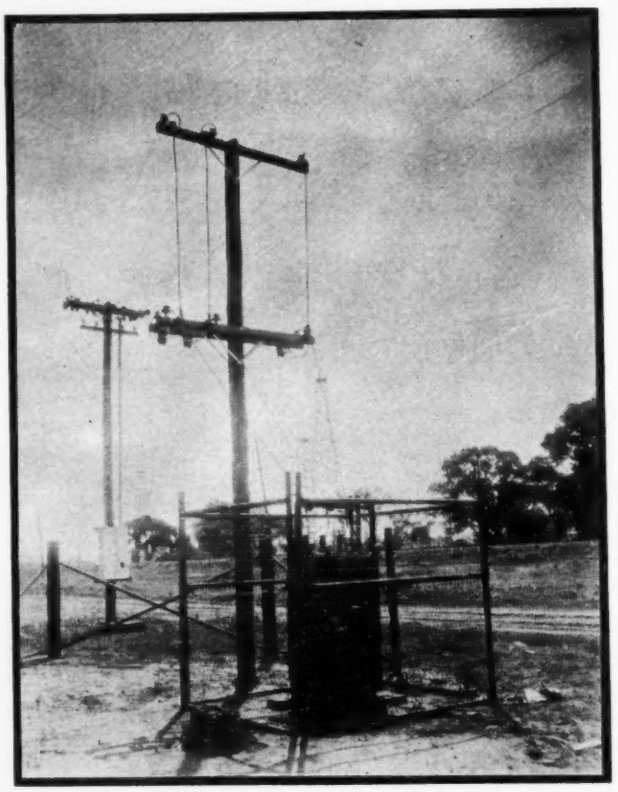
Size of units used, 50 to 75 hp.

Total operating time, 7750 days.

Average quantity fluid per day, 2200 bbl.

Total fluid pumped (approx.), 17,000,000 bbl.

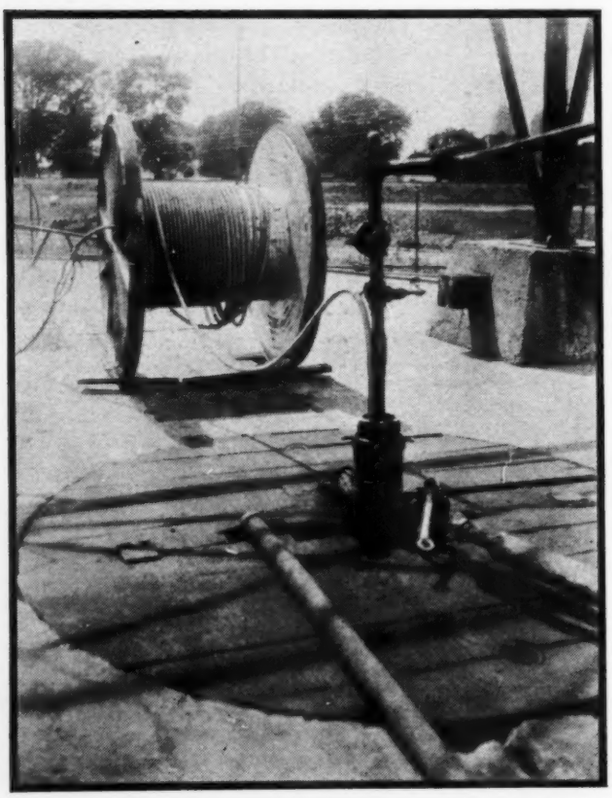
Average energy per 1000 ft. per bbl. of fluid, .3 kw-hr.



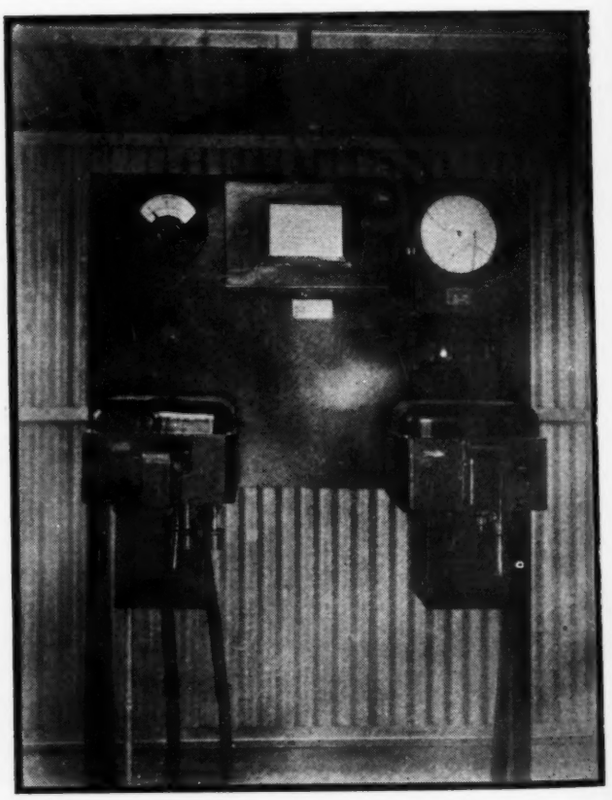
Typical supply substation, 4000 to 880 volts, 150 Kva.

Average repair cost per 1000 ft. per bbl. of fluid, .12c.

Among advantages other than these data show that can be accredited to this method of pumping, two are given: (1) Since the average length of time required to produce the monthly allowable in the Oklahoma City field under proration schedule has been approximately 13 days, obtaining of the allowable on each well produced by this method virtually becomes a certainty. (2) The rate of total recovery by this pumping method is exceptionally high, as illustrated by two typical examples: (a) Goodrich No. 1 Well, Sedgwick County, Kansas. Estimated recovery by beam pump prior to installation of this method, 160,000 bbl.; recovered by this method in 21 months, 383,300 bbl. (b) Coker No. 2 Well, Bebee Pool, Ada, Oklahoma. Estimated recovery in seven years of beam-pumping, 195,000 bbl.; recovered by this method in three years, 394,255 bbl.



Reda pump connected and in operation on a well. Reel for electric cable is the only necessary auxiliary equipment on derrick floor.



Typical control installation. The auxiliary oil switch is for disconnecting purposes only.

Electric Power in the East Texas Oil Field

By J. E. ELLIOTT
Southwestern Gas and Electric Company

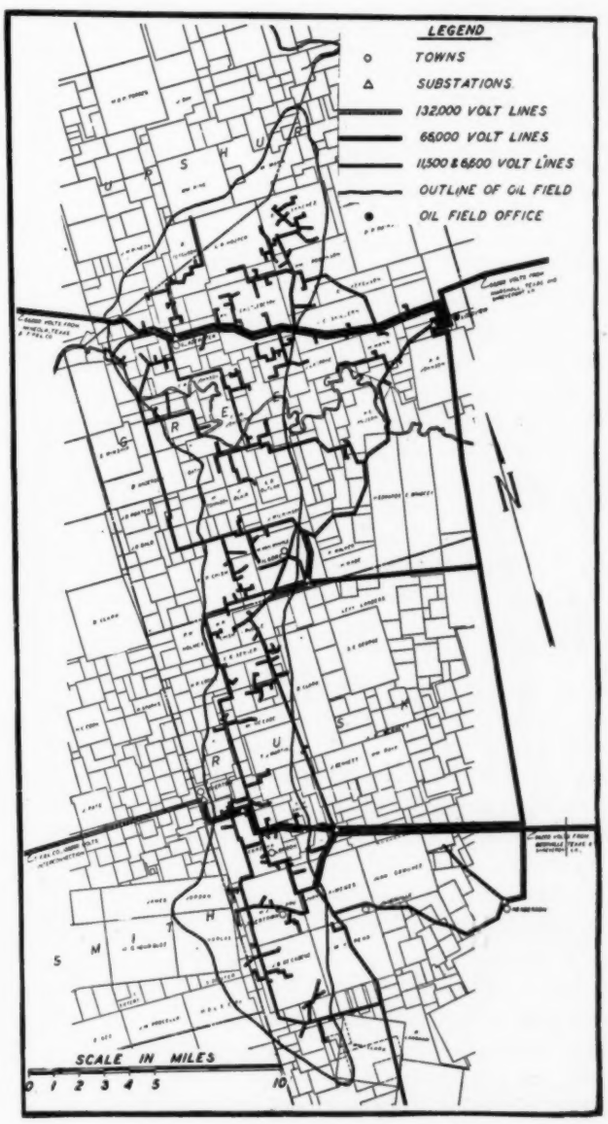
ELECTRIC power was found to be a necessity in the development of the East Texas oil field, because main pipe line pumping stations could be put into operation, and wells could be put on the pump with electric power without undue delay. When Southwestern Gas and Electric Company extended its transmission and distribution lines into this field, its principal objective was to render the best possible service at a cost commensurate with good business.

In practically every oil field power problem there is involved a certain amount of risk, whether it be pipe line pumping, oil-well pumping, or the numerous other applications of power. These risks show up in the final analysis of any power problem. When the oil industry purchases power, it transfers the power problems to the power company, where they properly belong. The oil operators are relieved of the care, worry, thought, and effort necessary in the production of power. Electric power companies are in a far better position to assume the risks involved in power installations than oil companies, due to their properties being interconnected and the diversity of their loads. In view of these conditions and the general convenience, cleanliness, and flexibility of electric power, most oil companies prefer to use it if they can do so economically.

For efficient operation oil companies demand as near 100 per cent service as possible. To provide this class of service a network of transmission and distribution lines was built to feed into the field from many directions. The accompanying map shows the transmission and distribution system in the field. There is available a total capacity of 74,500 kw. (100,000 hp.) in power plants and interconnections, this being sufficient for all present and probable future requirements in the field. Two major high-voltage transmission lines feed into the field from the east, one in the northern part and one in the southern. In like manner similar lines are connected to the field from the west side. In case of an interruption on the east, the entire load could be carried from the west, and vice versa. With such interconnections, there have been no major interruptions in the field since it was discovered.

A number of substations throughout the field transform the voltage from 66,000 to 11,500 volts for distribution. These distribution lines form a network throughout the field. Service is available on practically every lease from a number of different directions. If a difficulty is encountered on one distribution line, service can be obtained from another without interruption to the oil company.

Uncertainties regarding the result of federal control add to the oil companies' problems. These uncertainties, coupled with the general conditions in the oil industry, make it imperative that oil companies exercise unusual care in the selection of pumping equipment and in the form of power to be used. East Texas producers have already made heavy investments in leases, wells, rods, tubing, and other fundamental requirements. The fixed charges on these heavy investments are often very burdensome. When the time arrives to consider the type of pumping unit and power to use, they consider the first cost a major factor. As a prime mover, the electric motor has a very low cost per horsepower and, because of its light weight and ease of



Electric transmission and distribution in the East Texas oil field

handling, can be installed with a minimum of expense.

It is also important, because of present economic conditions, for oil operators to give considerable thought to operating costs. For this reason electric power must be competitive with other forms of power. When making the comparison, however, all the costs incidental to all forms of power should be taken into consideration. The advantages of each, which may not be calculable in terms of dollars and cents, should not be overlooked. There are a number of advantages derived from the use of purchased electric power upon which it is difficult to place an actual value. Accidents and fire hazards are reduced to a minimum. Electric motors require a minimum of labor to operate, have a long life and high salvage value, can be started and stopped in all kinds of weather by simply pressing a button, and require a minimum of warehouse stock of repair parts. Cost records on production are easily kept and they encourage efficient operation.

With many operators the cost of electric power is thought of in terms of operating costs only. Our experience would lead us to believe that proper thought is not given to the various items of expense that are covered by an electric power bill. No doubt an operator receives a definite and pronounced impression closely allied to an electric shock each time a monthly electric power bill comes to him for his approval; nevertheless, he would probably receive an equally severe shock if the repair items—loss of production due to shut down time, extra labor, etc.—were collected and their total presented to him for his approval. The latter items are perhaps seldom so collected and totalled, but are distributed to several separate accounts so that unless they are especially compiled their full significance is not appreciated. If the production man could have a summary of all these items at the time the power bill is presented, he would get a truer picture of production costs.

The various rates available in the East Texas field were designed to meet the desires of all customers. If desirable, the electric power company will furnish all transformers and any standard service voltage that might be required. For oil companies having a relatively high operating load factor, there is a rate form that gives the benefit of low unit costs to such operators. This rate is commonly termed the "demand type." It might be explained here that the fundamentals of any costs, and consequently of the price charged to the consumer, are the same in any business. Roughly, they are divided into two parts, overhead and operating costs. Overhead, of course, includes capital charges on investment, office, bookkeeping, and similar expenses. Operating costs include raw materials, labor, and maintenance, and depend upon the amount of the product, be it electricity or pencils that the seller has to offer his customer. Consequently terms employed by electric utility companies, and confusing to their customers, are "demand charge," "standby charge" and "current" or "energy charge." These terms may be confusing to the average person, but with a little study they resolve themselves into those two old familiar terms "overhead" and "operating costs." If the bewildered electric customer would substitute overhead for demand charge, and operating cost for energy charge, the electric bill resolves itself into a comparatively simple accounting statement.

The overhead, or demand charge, consists primarily of the capital charge on the equipment necesary to supply a given customer, together with the administrative and office costs. Obviously, the generating equipment and all equipment necessary to supply a 50-hp. motor will be almost double that necessary in supplying a 25-hp. motor. These facilities must be adequate to supply at any time the maximum call, or demand, that the customer might make upon the utility. Thus was born the demand charge.

The usage that is made of the power load determines the operating costs. If a motor operates 24 hours per day, it will obviously take twice as many units of production as if it operated for 12 hours, and the operating costs will be twice as much. The production units are measured in energy, or current, and the term used is current or "energy charge."

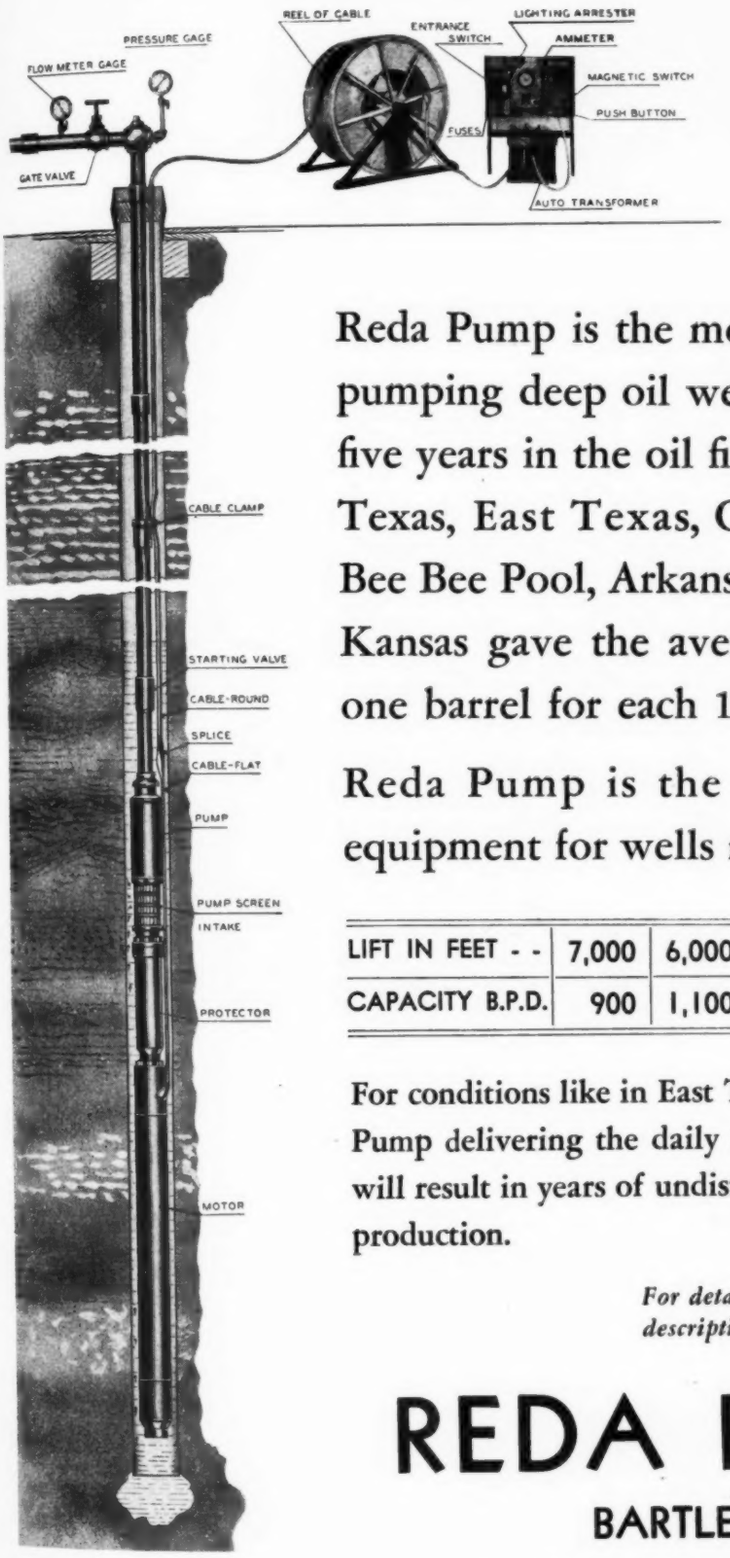
The objections to the demand charge have been overcome by the maximum simultaneous demand method of billing, necessary in East Texas because of the particular conditions in this field. Demand energy rates are optional with the consumers in East Texas, but it is through this form of schedule that benefits can be given for higher load factor operation. Load factor, another source of confusion to electric customers, is but an expression that engineers have coined to name the relation between overhead and operating costs. The oil industry is one that has an inherently high load factor, and should receive the resulting benefits from the electric utilities. For this reason, this form of rate is particularly adapted to the oil business. On this type of rate, the unit cost decreases as the operating load factor increases.

If, because of peculiar conditions in the field, the oil company is not able to operate at a high load factor, there is another form of rate based on the use of energy only, without a demand charge, that is beneficial to the consumer. In cases where the oil companies own the transformation and distribution lines on the various leases and different locations, the company will set a number of meters to measure the power and energy delivered to each lease. In determining the power bill all the energy used on the various leases will be added together and one bill rendered. This is equivalent to having all the energy pass through a single meter, although the leases may be scattered over a wide area.

Many companies believe that electric power has a decided advantage during the early pumping stages when large volumes of salt water are not encountered, but the objection is sometimes raised that electric power costs become too high when wells are required to pump large quantities of water. This factor has been taken into consideration by the Southwestern Gas and Electric Company in the designing of its rate schedules. The unit cost continues downward as the load increases. In other words, when large volumes of salt water are pumped the power requirements will be greater, and when more power is used the electric rate is lower, thereby offsetting to some extent this added cost to the oil industry of lifting water. It is believed that the unit costs of electric power are sufficiently low to enable the oil companies to continue the purchase of electric power, even under these conditions.

Electric power is adaptable to any and all operations of the oil industry, for the smallest motor and the largest. The service is now available on practically every lease in East Texas, or it can be made available upon short notice. In view of the uncertainties and changes in conditions, it is difficult for the oil companies to determine what should be the proper horsepower of prime mover to install on the wells. The use of electric power enables the oil companies to meet these uncertainties with a minimum investment.

100,000,000 BARRELS LIFTED



by REDA PUMPS. The only electrical oil well pump with both the motor and pump in a single unit at bottom of the well.

•

Reda Pump is the most economical method for pumping deep oil wells. Experience of the past five years in the oil fields of New Mexico, West Texas, East Texas, Oklahoma City, Seminole, Bee Bee Pool, Arkansas, and in different fields of Kansas gave the average overall cost of lifting one barrel for each 1000 feet of lift as one cent.

Reda Pump is the most powerful pumping equipment for wells not smaller than 6¼ inches.

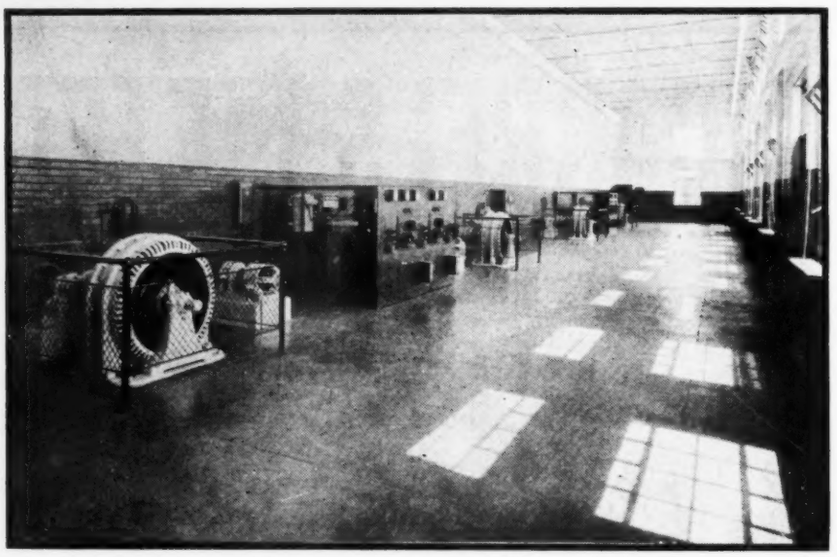
LIFT IN FEET - -	7,000	6,000	5,000	4,000	3,000	2,000	1,600
CAPACITY B.P.D.	900	1,100	1,300	1,600	2,200	3,200	4,000

For conditions like in East Texas the use of a large volume Reda Pump delivering the daily allowable in one or two hours' time will result in years of undisturbed and free from paraffin trouble production.

For detailed information and descriptive pamphlet, write . .

REDA PUMP CO.

BARTLESVILLE, OKLA.



Motor room of electric pump station on a gasoline pipe line

Historical Résumé of Electri

THE requirements for transportation of oil by pipe lines grew rapidly along with the petroleum industry as a whole. As new oil producing areas were discovered at locations remote from refineries and markets for refined petroleum products, the necessity for economic transportation of the oil over long distances in ever-increasing quantities, required that pipe line systems be developed to meet this necessity.

The first pipe line utilized the force of gravity to cause the oil to flow in the pipe. Obviously this method was limited to locations where there was a difference in elevation from one end of the line to the other and consequently was extremely limited. Steam-driven pumps were then introduced and pipe line systems extended. The use of the steam-driven pump increased rapidly and a number of pump stations using this type of equipment are still in operation.

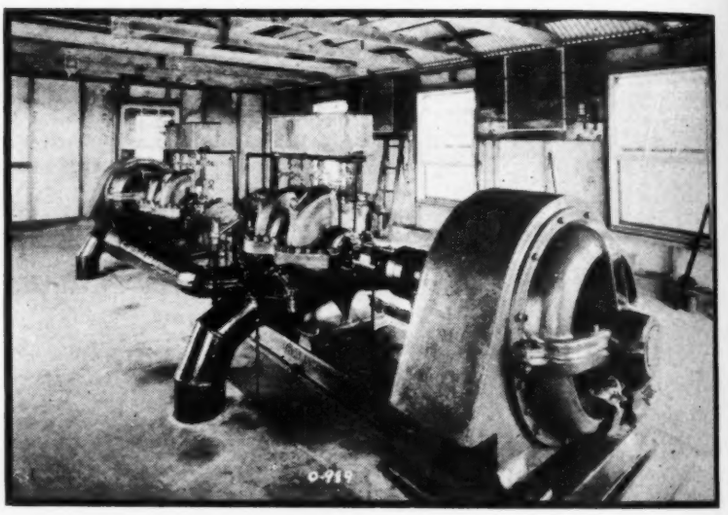
Later the Diesel engine appeared, was tried out on pipe line pumps and became the dominant type of prime mover for this service.

During the past 25 years, the electrical industry has also grown very rapidly. Power companies have increased their generating capacities many fold. Transmission lines have spread throughout the country so that dependable, economical electric service in large quantities has been available for many years at almost any location in the nation.

With this situation existing it was only natural that electric motors would be considered for driving oil line pumps sooner or later. In 1923, two motor-driven pumps were installed on a short pipe line in California.

At about this time and during the succeeding year, or two, several motors were installed to drive plunger pumps in pipe line stations in Oklahoma. Possibly at other places similar installations were made, although no general movement toward motor-driven oil pumps took place at this time.

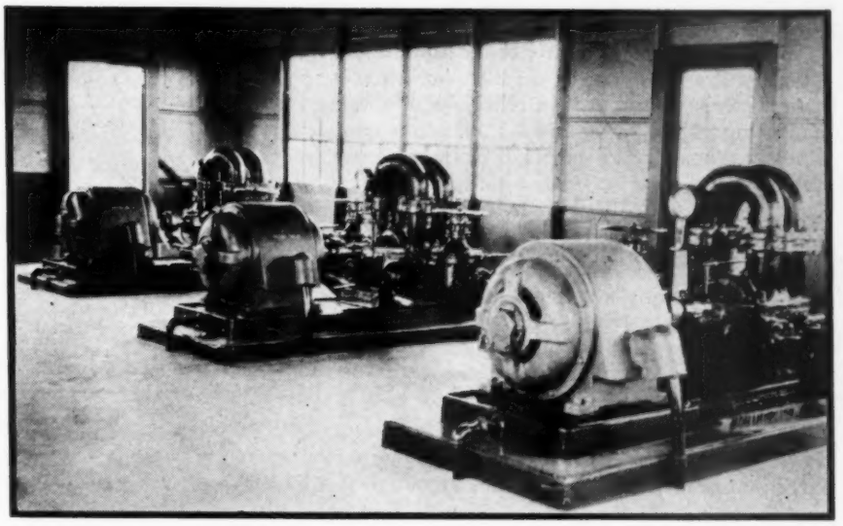
During these years, manufacturers of centrifugal pumps were working on the development of a centrifugal pump for oil line service that would handle oil in the quantities desired and at the high pressure required. In 1926 centrifugal pumps for handling oil under oil pipe line conditions were offered to operators; however, pipe line operators were very skeptical about this type of pump being able to do the work.



An early installation of a motor-driven centrifugal pump station at Henryetta, Oklahoma, installed early in 1927. Capacity approximately 30,000 bbl. per day at 600-lb. pressure

In June, 1926, one major pipe line company agreed to try out motor-driven centrifugal pumps in a main line. These pumps were installed in November of that year at Westbury, Texas, near Beaumont. The pumps, driven by 250-hp. 3600-r.p.m. motors, handled approximately 30,000-bbl. of Luling crude per day at approximately 550-lb. pressure. The operation was considered successful by the pipe line company.

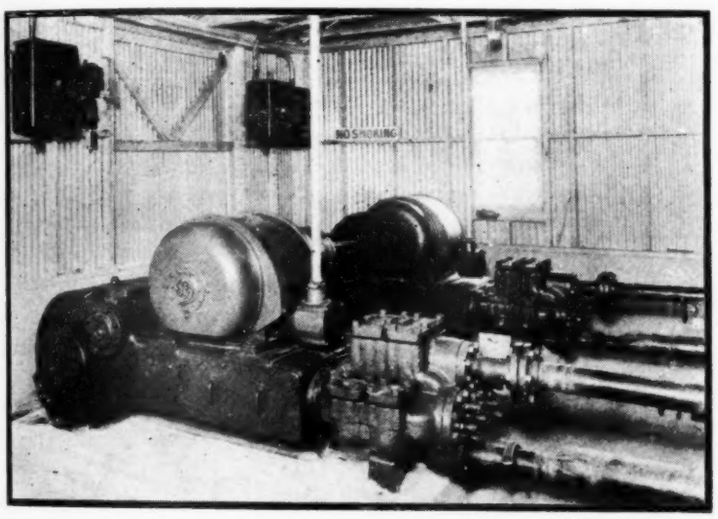
The necessity for this station disappeared, however, and this company moved two of these motor-driven centrifugal pumps to Kings Mill, in the Panhandle of Texas and installed them for trial on a pipe line handling Panhandle crude. This oil has a low viscosity and is easily pumped at temperatures of 70 or 75 deg. fahr. and higher, but has a very high viscosity at and below 60 deg. fahrenheit.



An early installation of motor-driven centrifugal pump station using one spare unit, at Bowie, Texas, installed in 1927. Capacity 30,000 bbl. per day at 550-lb. pressure.

ric Motors on Oil Pipe Lines

By
G. R. PROUT
General Electric Company



Two 50-hp. motor-driven reciprocating pumps installed on a gathering system in East Texas

These motor-driven pumps were installed in February or March, 1927, and started up on trial during the latter part of March. The oil handled was cold and practically solidified but the pumps moved about 22,500 bbl. against 650-lb. pressure during the first 24 hours to the surprise of many people.

These pumps, which are driven by 250-hp. 3600-r.p.m. motors, were put into regular operation in the Kings Mill station of this company in July, 1927.

At about this same period a pipe line company in Oklahoma was also considering motor-driven centrifugal pumps. This company installed two such units at Henryetta, Oklahoma, in February, 1927. The operation of this equipment was also successful. These pumps were driven by 300-hp. 1800-r.p.m. motors.

This started a very definite trend in oil pipe lining toward motor-driven pumps, of both the centrifugal and plunger types. This was due to the performance of the equipment in these installations coupled with the reliability of electric service and low first cost of the complete pump station using this type of equipment.

In 1927, '28 and '29 several pipe lines that used motor-driven pumps, both reciprocating and centrifugal, were built to take oil out of the West Texas producing area to loading docks on the Gulf Coast or to refineries.

It is estimated that the total capacity of pipe lines constructed to move oil out of West Texas, on which motor-driven pumps were used in part or in whole, was approximately 300,000 bbl. per day. The total electric motor horsepower installed to drive pumps on these lines was approximately 85,000.

This indicates the degree of acceptance by the oil pipe line companies, of the motor-driven pump during this period.

In Oklahoma, Arkansas and other states, as well as in Texas, motor-driven pump stations were being installed during this period.

While a large number of motors were installed with reciprocating pumps, there was a very decided swing toward motor-driven centrifugal pumps. This was largely due to the fact that the motor-driven centrifugal pump is a relatively small, light, inexpensive unit. It is easily and quickly installed, requires a small building and no surge tank, has low maintenance cost and requires a minimum of labor to operate. This type of unit is easily moved from one location to another and later developments proved the desirability of this feature.

When the necessity for moving large quantities of oil out of West Texas disappeared, several companies moved motor-driven centrifugal pump units to new locations on pipe lines that moved oil out of other producing areas. Some of these units were moved several times. One company moved units

of this type from Oklahoma to West Texas, later moved them back to Oklahoma again and then moved them to East Texas.

During this period, not only did the electric motor-driven pump prove its worth to the oil pipe line industry, but the power companies proved the reliability of their service.

During 1929, '30 and '31 several companies installed gasoline pipe lines varying in length from 200 to 800 miles. Many motor-driven pumps were installed on these lines and two companies installed only electric motor-driven pumps on complete gasoline lines.

The centrifugal pump manufacturers continued to do research work, and pumps with improved mechanical features and better efficiencies were developed. Also the number of sizes of pumps increased so that centrifugal pumps became available that could handle capacities from 8000 bbl. per day against 350-lb. pressure up to 80,000 bbl. per day against 400-lb. pressure. Two of these small units in series can handle 8000 bbl. a day against a pressure of 700 lb. while two of the large pumps in series would handle 80,000 lb. per day against 800-lb. pressure. Efficiencies of from 70 to 85 per cent were obtained with these pumps handling crude oil, the higher efficiencies being obtained on the larger pumps. The efficiency of the electric motor is about 92 per cent at full load.

This development caused even a greater acceptance of the centrifugal pump by the oil pipe line companies.

Since the centrifugal pump is essentially a high-speed machine when handling large volumes at high pressure, and since the electric motor is readily designed and built to operate at high speeds, it was quite natural that the centrifugal pump direct-coupled to an electric motor would become the common pumping unit. Most of the pumps that have desirable efficiencies are 3500- or 3600-r.p.m. machines.

In some cases, where electric power was not readily available from power companies, pipe line operators installed centrifugal pumps with Diesel engines. However, since the centrifugal pump is a high-speed machine, while the Diesel engine is a relatively slow-speed machine, it was necessary to install between the engine and pump some device for increasing the speed. In some cases speed-increasing gears were used, but in others electric generators were direct-coupled to the slow-speed engines and high-speed motor-driven pumps were used.

There are several advantages to be gained by the use of the engine generator-motor-driven centrifugal pump type of station, where purchased electric power is not available. Pipe line operators, who consider their problems from the standpoint of the business of transporting oil through an extensive pipe line system, instead of considering each pump station problem by itself, appreciate these advantages.

Since electrical equipment lends itself so readily to automatic control, it was natural that the application of automatic features would be incorporated in pump stations using electric power.

At first, automatic equipment was installed to shut the pumps down under certain emergency conditions. This type of equipment is relatively simple and inexpensive. Consequently, nearly all electric pipe line stations are equipped with devices to shut the pumps down under one or more of the following conditions: Loss of suction pressure, loss of discharge pressure and excessive discharge pressure. The first condition might be caused by the shutting down of the upstream station or the breaking of a line on the upstream side; the second condition would be caused by a break in the line on the downstream side, while the third condition would be caused by the operation of the pumps against a closed gate valve or the building up of pressure due to shutdown of one or more pumps in the downstream station.

In 1927 one company attempted to control, automatically, the complete operation of a motor-driven centrifugal pump booster station by means of pressure in the line. This problem was a little more difficult due to surges caused by plunger pumps in upstream stations and other conditions of operation. However, the results obtained showed that it would be possible to control automatically, the pumps on a pipe line, where all pumps on the line were motor-driven centrifugals.

In 1928 and '29 considerable thought was given to the use of automatic supervisory control applied to pipe line operation. This type of control, which permits automatic starting and stopping of electric machinery at points remote from the operator, has been used extensively for other applications such as the remote operation of rotary converter substations on street railway systems in large cities. This arrangement permits a dispatcher at a central location to put machines located at various remote points on the system or take them off at will. It has also been used in connection with water-wheel generator stations located at remote points on a generating system. Here again the dispatcher at a central location can open or close gates, start and stop generators and otherwise control the operation of the station located many miles away.

This type of equipment with certain modifications could be applied quite readily to the remote operation of motor-driven pump stations. After careful study of the problems encountered in pipe line operation, two or three installations of this type were made and the operation was successful.

The world-wide depression was just reaching this country when this development was taking place, consequently no further work has been done along this line; however, when conditions improve it is likely that continued activity in the application of remote supervisory control equipment will take place.

While pipe line companies were becoming such large users of motor-driven pumps on main lines, they were also realizing the advantages to be gained by the use of motor-driven pumps in gathering systems.

During the development of the East Texas producing area a large number of motor-driven gathering pumps were installed. This was also true in other fields.

In many cases the automatic features that can be used in conjunction with this type of equipment on gathering systems make it so desirable as to exclude other types of prime movers. In many cases, the gathering pump is capable of pumping out a tank in less than 24 hours. Consequently, the gauger gauges the tank, determines how long the pump should run to pump the tank out, sets a time switch to stop the motor the proper number of hours later and starts the motor. The gauger can then go to the next location and do likewise. He need not return to any pump until the following day. This reduces gathering costs materially.

At the present time it is estimated that there is in excess of 200,000 hp. in electric motors installed on pumps in main line oil or gasoline pipe line stations. These motors range in size from 150 to 1000 horsepower.

The foregoing figure shows that the degree of acceptance of motor-driven pumps in main line work as well as gathering work by the pipe line companies has been very high. The advantages to be gained by the use of this type of equipment is realized by many of the executives and operators of pipe line companies, it is therefore to be expected that pipe line companies will use electrical equipment even to a greater degree.

Largest Direct-Current Rotary Drilling Rig Is In Operation In Oklahoma

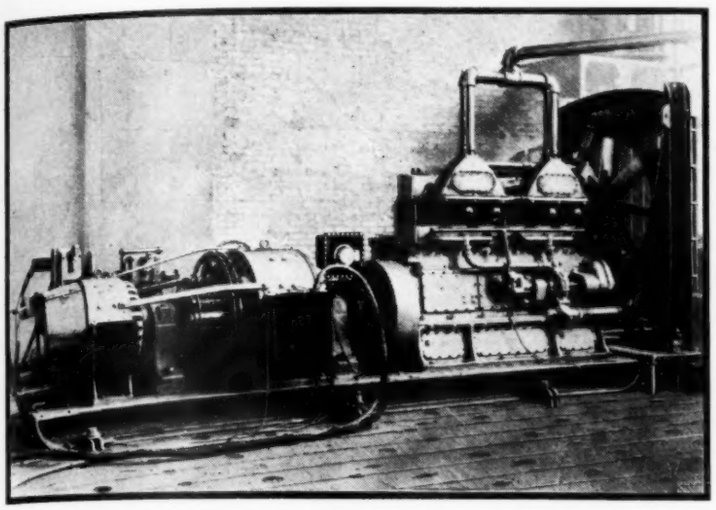


Fig. 1. 325-hp. gas engine driving a 150-kw. and a 70-kw. d-c. generator

By W. C. LANE[1] and D. M. McCARGAR[2]

THE first application of the Ward-Leonard or variable voltage system of speed control to rotary drilling was made about four years ago. It has appeared to those who have been in touch with the developments along this line that the method has advantages possessed by no others and that it will soon be in general use. The first units were designed for light work and no provisions were made for the continuous operation of the rig in case it was necessary to shut down one unit in order to make repairs. The evolution of the system has been rapid and has resulted in a marked increase in the capacity of the equipment involved and in an arrangement whereby service can be maintained with only one unit in operation.

The Ward-Leonard system is based on the principle that the speed of a direct-current motor is proportional to the voltage impressed over its armature when its field is kept constant and that under this condition the torque it will develop is independent of the speed of rotation. A motor can be caused to exert as great a pull while at rest as when it is rotating at its full-load speed. In applying the method it is necessary to provide at least one generator for each motor to be operated, and in addition a small unit to excite the fields of all the motors and generators involved. A motor is started, stopped and reversed by means of a small rheostat connected in the field of the generator used to drive it. The electric circuit serving a motor is never opened during its operation.

Internal combustion engines are used to drive both the main generators and the exciters so that each rig is complete within itself and is independent of power lines. The rigs can be operated wherever it is possible to transport ordinary rotary machinery. Both the fuel and the water problems are greatly simplified since engines have been developed that will utilize whatever grade of fuel that may be available and require only a small quantity of good water for cooling the engines. Any kind of water is suitable for mixing the mud.

The heaviest installation of this kind to be put in operation is the second Ward-Leonard rig to be purchased by the Arrow Drilling Company of Tulsa and is being used to drill a wildcat well in Pottawatomie County, Oklahoma. The well, Amerada Petroleum Corporation and Stanolind Oil and Gas Company No. 1 Goodman, is located one mile east and three miles north of Shawnee. The electrical equipment was supplied by the Allis-Chalmers Manufacturing Company; the engines are from the factory of the Waukesha Motor Company.

Each of the two main generating units similar to that shown in Fig. 1, consists of a 150-kw. and a 70-kw. generator, each rated at 175 volts, 850 r.p.m., differentially wound, open

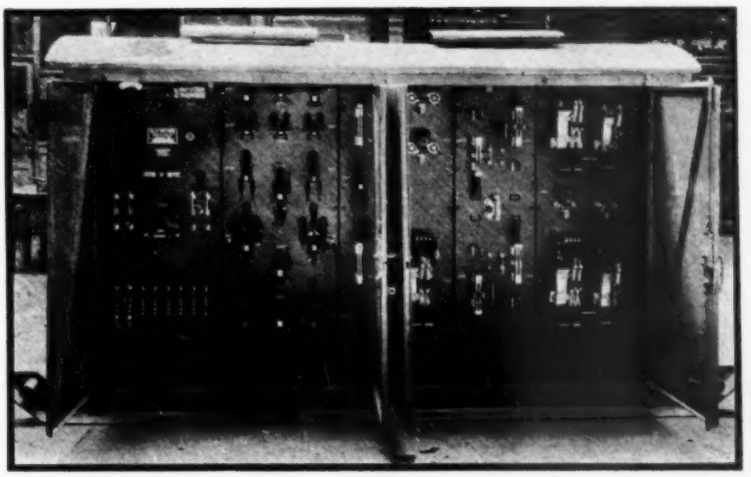


Fig. 2. Control equipment for operating two duplicate generating units of Ward-Leonard system

[1]Consulting electrical engineer, Tulsa, Oklahoma.
[2]Allis-Chalmers Manufacturing Company, Tulsa, Oklahoma.

type, 40 deg. for continuous service. The two generators are mounted on the same shaft and are coupled to a 325-hp., 900-r.p.m., 8½-in. x 8½-in. 6-cylinder gas engine. The weight of each unit as shown is 26,000 pounds. Two exciter units are provided, each of which consists of a 25-kw., 125-volt, 1150-r.p.m. compound-wound, open-type, 40-deg. generator direct-connected to a 60-hp. 6-cylinder gas engine. The generator control equipment shown in Fig. 2 is mounted in a steel weather-proof cubicle mounted on steel skids.

The main engines are started in rather a unique but effective way. The two generators in a unit are connected in series and are operated as series motors by current from one of the exciter units.

The radiators for the main engines are assembled in separate units and are set several feet away from the engines. Two 2-hp. 125-volt motors driven from the exciter and controlled by thermostats located in the radiators are used to operate the cooling fans. The two thermostats are set to operate at different temperatures so that one motor will run practically all the time and the other will start up only when it is needed. This arrangement eliminates the frequent starting and stopping of a 4-hp. motor.

The main cables used to carry the electric current from the cubicle to the motors are enclosed in a wooden conduit. Each cable of a motor circuit consists of two 500,000-cir. mils stranded conductors. To those who are not accustomed to think in mils it may be said that if a solid copper rod of an equivalent cross section were used each cable would be one inch in diameter. Tirex cables are used for the control wires and are drawn through a 2½-in. fire hose and then enclosed in the wood conduit. Copper lugs are soldered on each cable terminal and each has been stamped so that it may be identified and connected to the proper post when the rig is moved to a new location.

The drilling and hoisting motor is assembled as in Fig. 3, and is rated at 400 hp., 350 volts, 1000 r.p.m., 50 deg. for one hour operation, and 200 hp. at 175 volts, 500 r.p.m. It is totally enclosed and is ventilated by a blower operated by a 2-hp. motor driven from the exciter. The blower unit is attached permanently to the motor frame and provisions are made for obtaining the cooling air through a pipe at a distance from the rig in case gas is present. It will be noted that the motor can be supplied with a maximum amount of air while operating at any speed or while it is simply holding a load at rest.

Each of the two pump motors, mounted as shown in Fig. 4, is rated at 275 hp., 350 volts, 1000 r.p.m., 40 deg. continuous service and at 137½ hp. at 175 volts, continuous service. Doubtless they will carry 150 hp. or more with ease on 175 volts. They are enclosed and ventilated in the same manner as the drilling motor and are identical to it but their operation includes a cumulatively-connected series winding. One of these may be regarded as a spare to replace the drawworks motor in case of an emergency.

The control apparatus for the motors occupies a very small space on the well floor as is shown in Fig. 5. Each of the two pipes leading from the assembly shown to the driller's position consists of a tube within a tube, each of which terminates in a light handwheel. A small master drum not shown in this picture and an emergency stop button are also placed near the driller. As a protection against fire all the control apparatus has been made explosion-proof.

It is natural for one to ask the question as to why 70-kw. and 150-kw. generators are used on each unit. An investigation of the power required to

ELECTRIC POWER SERVICE

for **Production**

Pipe Line

Refining

As DEPENDABLE as good engineers can make it

As ECONOMICAL as good managers can make it

As FRIENDLY as good friends can make it

●

GULF STATES
UTILITIES COMPANY

General Offices:

BEAUMONT, TEXAS and LAKE CHARLES, LA.

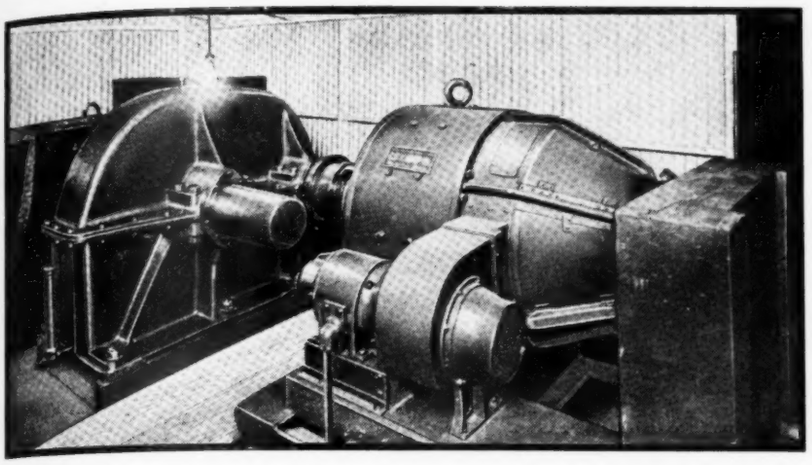


Fig. 3. 400-hp. hoist and drilling motor. Note ventilating equipment

rotate the pipe on ordinary drilling work will show that 70 kw. is within the range of much of the drilling done. The capacity of the large generator was chosen so as to give a balance to the units under all the possible ways in which they are operated.

The flexibility of the rig can be appreciated best by a consideration of the elementary wiring diagram shown in Fig. 6. The basic ideas are shown on this sketch but no attempt has been made to give the exact details of the wiring. In the sketch, KS1, KS2, and KS6 are knife switches located in the cubicle and are hand-operated. M1, M2 and M5 are magnetic switches operated by an electric current from the master drum situated near the driller.

As a matter of clearness it should be said that certain magnetic switches are so arranged that it is impossible to close one while another is closed. For example, M1 and M3 are paired so that if M1 is closed M3 will be held open, and vice versa; the same is true of M2 and M4. Let it be assumed that the crew is ready to spud in and that only one unit is to be operated. The engine on the exciter will be cranked by hand and energy from it will be used to start the main engine on Unit No. 1. Switches KS1, KS2, KS3 and KS4 will be closed upward, also the pump switch KS5 will be closed. The driller will set the master drum on the "drilling and pumping" position, which will close M3 and M5 when the control rheostats are on the position for zero voltage. He will then operate the handwheel, which controls the field on generator No. 1 and causes it to produce a voltage that will send a current through pump motor No. 1 thus causing it to rotate at a speed proportional to the voltage supplied. Since the connections for the drawworks motor were set up by the master drum, the drawworks motor can be started from generator No. 3 in exactly the same manner by manipulating the handwheel governing it. When it is necessary to come out of the hole the master switch will be set on the "hoist" position, which opens M5 and M3, and closes M1. This changes the hoisting motor to the 150-kw. generator.

Had the knife switches been thrown down the load would

EXPERIENCE / ECONOMY / CAPACITY

We have been serving all branches of the petroleum industry ever since petroleum has been a major resource in our territory.

We are prepared to supply expert, economical and adequate service for present and future activity in the area we serve. Additional capacity will be made available as needed.

KANSAS GAS AND ELECTRIC COMPANY

WICHITA, KANSAS

Why

Purchased Electric Power Will Lower Your Lifting Costs

Electric pumping equipment will outlast the well itself. Original units installed in the Goose Creek Oil Field have been operating twenty-four hours a day for over twelve years without major repairs and for less than Fifteen Dollars a year per well in total electrical maintenance costs.

◆ ◆ ◆

These electric pumping motors will still deliver their full rated horsepower output continuously and will handle, without difficulty, increasing well power requirements due to water encroachment.

◆ ◆ ◆

Obsolescence has had such a negligible part in raising operating costs during the past twelve years that its effect may be disregarded. In fact, these veteran motors are regarded as suitable units, without general reconditioning, for new well service.

◆ ◆ ◆

Careful records of rod and rig troubles indicate that service work to keep these electrically-pumped wells in continuous operation has been held to a remarkably low figure.

◆ ◆ ◆

The salvage value of this electrical pumping equipment is so nearly one hundred per cent that the loss incurred due to a transfer from well to well is lower than with any other form of power.

◆ ◆ ◆

These are only a few of the reasons why THE TREND IS TOWARD PURCHASED ELECTRIC POWER.

Houston Lighting & Power Company

General Offices . . Houston, Texas

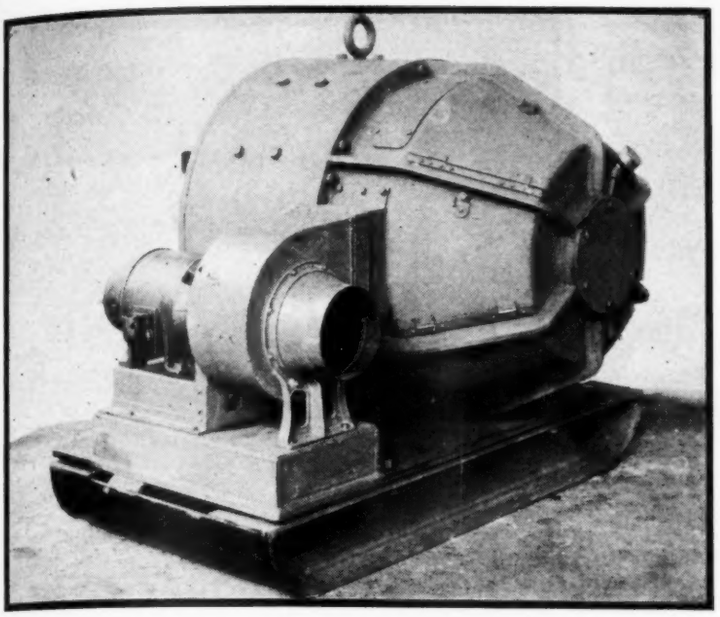


Fig. 4. 275-hp. d-c. mud pump motor

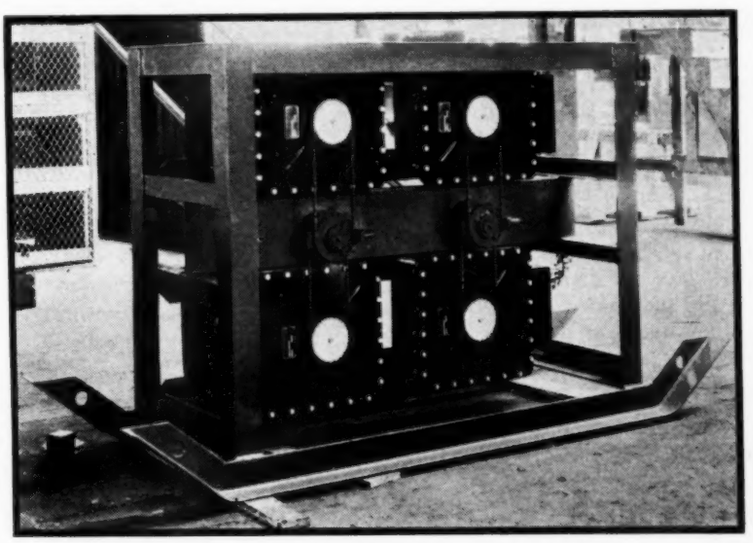
It will be seen from what has been said that the exciter unit is the heart of the whole system. All speed regulation is based on its use, it is used to operate the blowers on both the engine radiators and the pump and drilling motors and to light the rig. That a stand-by exciter unit is justified seems self-evident.

The function of the differential field windings shown in Fig. 6 is to protect the engines and generators from excessive overloads. In making a hard pull the operator increases the voltage of the generators but the effect of the differential fields is to decrease it. The driller controls things up to a certain load within the capacity of the engines, at which point the matter is taken out of his hands automatically.

If at any time it is wished to operate such a rig from an alternating current power line the engines may be replaced by squirrel cage induction motors.

It appears from the data available that this rig has ample capacity for drilling wells of any depth within the limits of modern practice. Economy in fuel and water, and the flexibility and ease with which it can be adapted to an emergency make it a valuable tool for use in the development work of the oil industry.

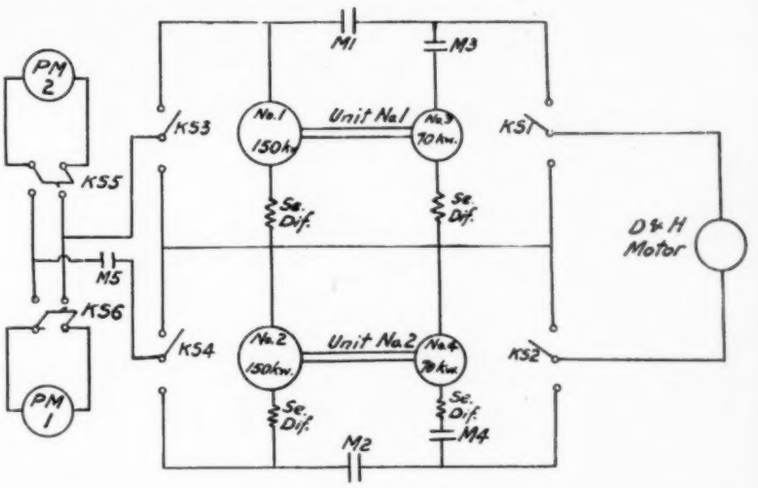
have been thrown on Unit No. 2 and it would have been controlled in the same manner as Unit No. 1. Suppose now that the hole has reached a depth where more power is required for drilling and pumping than one unit is able to generate. The second unit is started as described above for Unit No. 1, switches KS1 and KS3 are closed upward and KS2 and KS4 downward, thus throwing the two 70-kw. generators in series for drilling and the two 150-kw. generators in series for pumping. The drilling and hoisting motor now has a capacity of 140 kw. available and the pump motor 300 kw. available. When hoisting work is to be done the master drum is set as before but this time both M1 and M2 are closed. In operating the generators in series their handwheels are locked together and are operated as one. Obviously the voltage will be doubled and the speed of the hoist motor will be doubled. In order that the speed of the pump motors will not be doubled their exciting current is increased automatically by a relay that short circuits resistances connected in their fields.

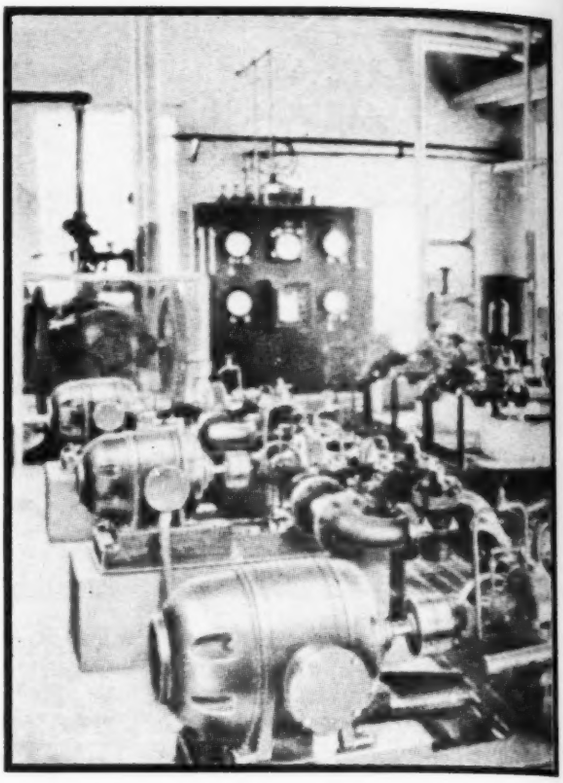


Left—Fig. 5. Control unit for applying the output of four generators to the drilling, pumping and hoisting work of a rig.

Below—Fig. 6. Elementary wiring diagram showing basic operations of Ward-Leonard system used on this installation.

A study of the wiring diagram will show that the apparatus provided offers a maximum flexibility of operation. There are eight different operating combinations available for meeting any conditions of operation that may arise in drilling a well. Each unit has ample capacity for operating the rig but at a reduced rate in case the work is heavy. The thing that is most impressive is that practically all the energy supplied to a motor at any time is converted into mechanical energy and put in action at a speed at which it can be utilized to the best advantage. This is possible with no other type of drilling equipment.





Three explosion-proof induction motors direct-connected to centrifugal pumps in a large refinery

Uses of Electricity In Refineries

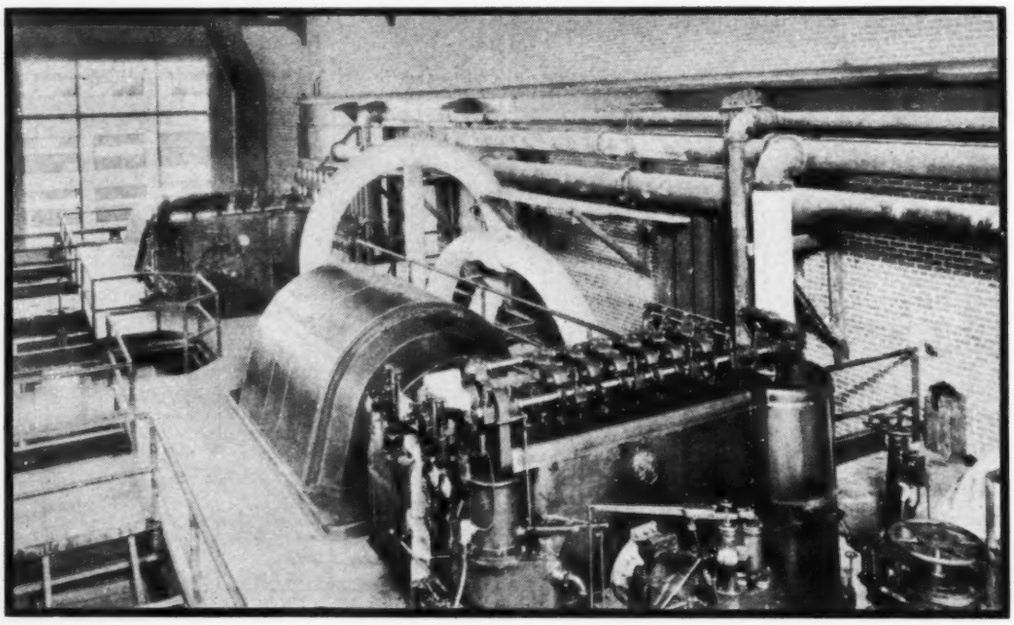
THE present tendencies toward high pressures and high temperatures in oil refining have made it absolutely necessary to have an adequate and reliable supply of electricity to meet the exacting requirements of the modern refinery of today. The electricity may be either manufactured or purchased, or both, as in the case of some refineries, whose constantly increasing demand has outgrown the capacity of their present generating units.

Most refineries have a source of cheap fuel and therefore find it very advantageous to manufacture their own electricity, using a turbine-driven generator as a prime mover. Of the turbines there are several types well adapted to refinery needs. The back-pressure type may be used very economically where a considerable amount of low-pressure steam is required for processing the oils.

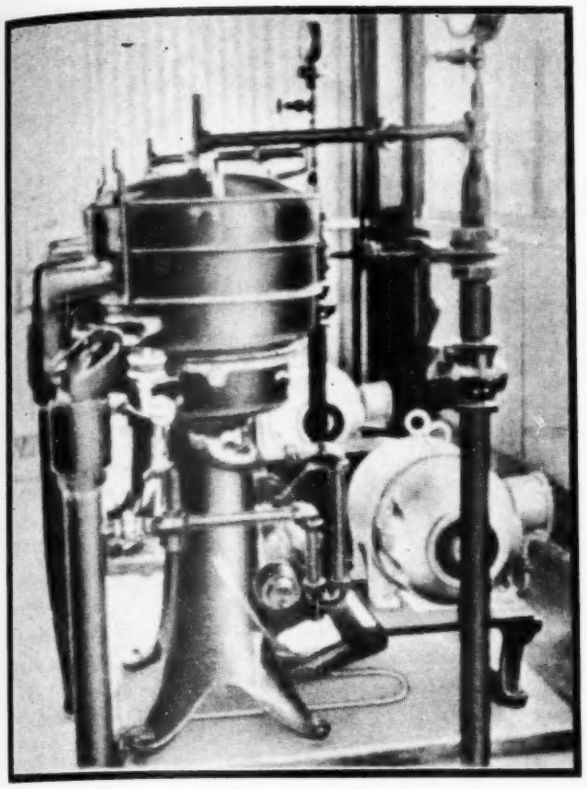
The bleeder type turbine may also be used, as steam can be bled from one of the stages to give the desired pressure for the processing work. There is also another type known as the mixed-pressure turbine, adaptable to plants having a surplus of exhaust steam from other sources.

The principal uses of electricity in the refinery are to supply power for motor-driven pumps and air compressors, and to supply a lighting system. The pumping load in the refinery requires the major portion of the electricity used, as the oils are handled many times during the process of refining, and large quantities of water for cooling purposes must be pumped each day. The source of this water is usually either from wells or a nearby stream, as the price of purchased water for cooling purposes is, in most cases, prohibitive if the make-up is of any great quantity, due to losses by evaporation, winds and waste.

Compressed air has many uses in the refining of oils, among which are agitating, blowing acids, blowing out oil lines, driving reciprocating pumps, hammers, drills and caulking tools, and also pumping water by means of the air lift. The source of the air supply is motor-driven air compressors, pre-



Two 7500-kw. non-condensing, double-automatic extraction steam turbine-generator sets in a large refinery in the Gulf Coast



Two induction motors, each driving a centrifuge in the acid plant of a refinery

By

HARRY L. VAN BRADT

Electrical Engineer

Tulsa, Oklahoma

ferably driven by synchronous motors, as they operate at constant speed and their power factor is at all times under the control of the attendant, therefore they can be used to correct a low power factor in the system resulting from the use of many small motors, required in the refinery.

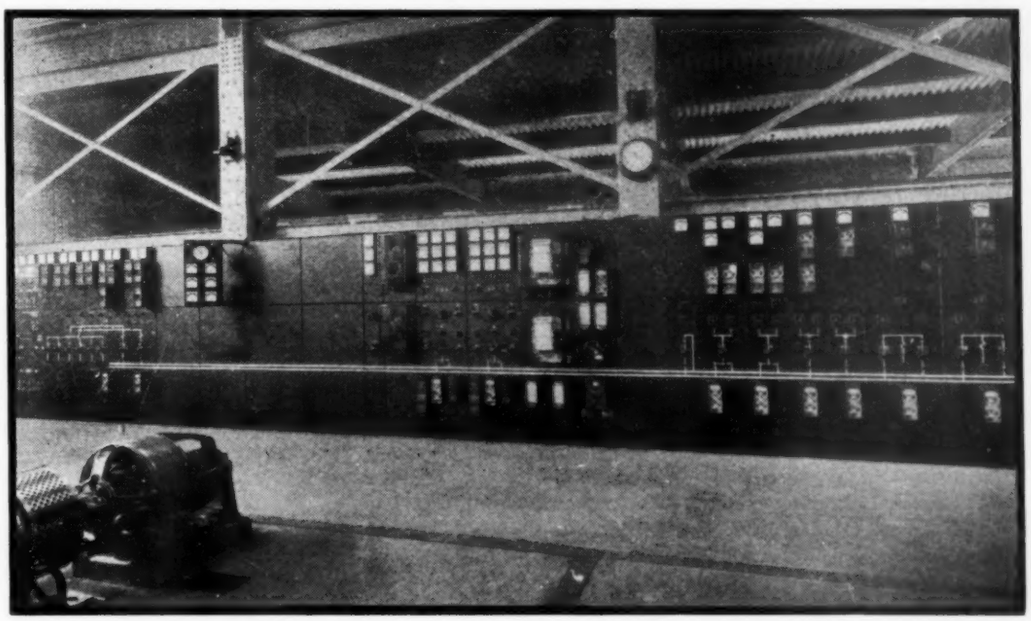
Due to the coöperation of the manufacturing engineers, the refinery engineers are finding many new uses for motorized equipment, especially since the introduction of the explosion-proof, totally-enclosed induction motors, listed by the Underwriters' Laboratories for Class 1, Group D, hazardous locations, suitable for use where inflammable or volatile liquids and gases are handled, thereby reducing the fire hazard to the minimum. This type of motor has been known to have withstood some very severe fires without apparent damage except to the paint on the outside of the motor.

The splash-proof motor has been found very adaptable for driving centrifugal water pumps, as it cannot be injured by water from leaky glands and stuffing boxes.

The weatherproof motor has proven itself very economical in refinery work, as it can be installed any place out-of-doors, thus eliminating the cost of a building to protect it. Since it is weatherproof, it is especially adaptable to the pumping out of tank bottoms, as it can be readily moved from tank to tank, thereby reducing the losses due to condensation in long steam lines to reciprocating pumps used for this service.

Outdoor lighting is best accomplished by flood lights having weatherproof metal cases, with insect-proof doors and good reflectors. Inside illumination should be of vapor-proof construction, consisting of safety switches, conduit and cast-iron or other metal fittings having a strong glass globe and gasket able to withstand the explosion of the light bulb without damage.

There are many other uses for electricity in a refinery, such as motor-driven pyrometers, CO_2 machines, long distance recorders, remote controls, laboratory testing equipment, electric welding machines and machine shop equipment.



Main switchboard and remote metering panel installed in power plant of a large refinery in Texas, where refinery power plant and central station high lines are tied together

Petroleum Industry's Exhibit A Feature of World's Fair

ON May 26, the 1934 edition of A Century of Progress Exposition opened its gates by popular request. This encore was demanded by the enthusiastic visitors of last year —from President Roosevelt and countless others. Yet it is by no means the same World's Fair. In every way it has been added to, replanned and reconstructed, profiting by the experience of last year. The exhibit of the American Petroleum Industries, covering 6000 sq. ft. in the Hall of Science, has been retained. This feature, one of the most outstanding in the Science Building, has likewise undergone complete overhauling and refurbishing. So popular and so instructive was it acclaimed last year that no basic changes have been made. The same committee who so ably spent months of research in preparing the exhibit for its initial showing are responsible for its 1934 appearance.

Ideal Oil Field Diorama

The first exhibit, which serves as an introduction, acquaints the public with a modern oil field under ideal conditions. Derricks are lined up along property lines. Every piece of equipment used in the field is shown in miniature—storage tanks, slush pits, oil field pipe lines, warehouses, etc. The topography shows slight offsets suggesting a fault. Below the field, the "earth" has been cut away, and water, oil and gas are shown being drilled. All this is animated—the flow of the liquids and gas through glass rods. Taken from the east side of the Coalinga oil field in California, this diorama has been modified to give a perfect expression of oil geological principles.

The use of dioramas last year brought a clearer understanding of all the processes. An actual foreground, composed of models in scale graduates into a painted background. Several of these are used, one being 18-ft. wide by 12-ft. high. Subterfuge to gain true effects is the paradoxical principle employed throughout the exhibits. Oil and gasoline, for example, are really colored water, and 79 motors, 49 pumps, seven air compressors, four sound mechanisms, four synchronized lighting devices and two scenic projectors are used to work the models and make their functions realistic.

Various other oil fields are also to be shown, to illustrate unusual conditions. A diorama of a scene in Mexico will demonstrate oil seepage, the gas bubbling to the surface through a pool of water. The Turner Valley field of Canada and an Oklahoma field representing two other kinds of geology also are illustrated.

Sub-Surface Exploration

Drilling for oil wells is associated in the public mind with wildcats, with unexpected gushers, and with a good deal of luck. Sub-surface exploration replaces this old romantic notion with a newer mystery having fully as many thrills and all the intricacies of present-day discovery. One exhibit is devoted to the mapping of oil structures by explosion waves, explaining the seismic reflection and refraction methods. The Torsion Balance, used principally in the search for salt domes, is also the subject of an interesting display.

Drilling Methods

Next the visitor is initiated into the devious methods of drilling for oil and gas. Full size standard tools and equipment are placed before large models, which show both actual drilling operations and the use of various tools.

It is pointed out, for example, that the Diamond drill is used to reach depths of 6000 feet or less. Hydraulic feeds, larger bits, cable-tool rigs and derricks, "miniatures" standing 13 ft. high, are animated, and continually working. The problem of fishing for tools, that costly and dangerous operation, is explained; a model of an exceptionally crooked hole displays how it is surveyed, the instruments, such as the Sperry gyroscope, that are used, and the causes of crooked holes. Models and charts illustrate the cementing of casings.

Pumping

In a large glass-enclosed case, which allows the observer to see the sub-surface, is a model of a central power pumping unit. Four wells are connected, and through glass casings the oil is seen rising from the "pay" sand.

The recent adoption of water-flooding of sands to increase the yield of depleted fields is the subject of an interesting exhibit, which shows the methods used in keeping with the conservation of this great natural resource. The model is constructed from the project at Bradford, Pennsylvania.

Model Refinery

One of the most interesting exhibits of the industry is centrally placed in the main room of the Hall of Science. Major refining operations, from the fractional distillation of crude oil to the final treatment of the five basic products, and including the cracking process, are demonstrated in a glass-enclosed model refinery, which extends 30 ft. in length.

Towers, stills, tanks and pipe connections are cut away, and covered with glass, so that a trip around this small refinery discloses all the actions of modern methods. The separation and collection of crude oil vapors of different weights are vividly explained by bubbling liquids within the transparent tower. Another section demonstrates the treatment, chilling, and dewaxing of lubricating oils, as well as the final stages, in the asphalt and coking stills.

Transportation

Because distribution is one of the major problems of any industry today, and particularly because of the extremely complex combination of pipe line, water and rail transportation in the petroleum industry, a large model shows a terminal that combines all these facilities. A group of translites near by traces the development from the early days of horse-drawn tank wagons and tankers, which were then sailing vessels, to the modern transport methods of today. Illuminated maps complete the exhibit, giving the visitor a comprehensive idea of world gas and oil fields, and their relation to markets, through the medium of transportation.

Elements of Applied Petroleum Refining

By W. L. NELSON

Professor of Petroleum Refining,
University of Tulsa

Article VIII

TYPICAL FLOW DIAGRAMS AND OPERATING DATA

(Continued)

CENTRIFUGING, TREATING AND RE-RUNNING BRIGHT-STOCK SOLUTION

PROCESSING Cylinder Stock. The major operations that are involved in the production of bright-stock from cylinder stock are as follows:

(1) Dilution with naphtha.
(2) Filtration by the contact or percolation method.
(3) Chilling followed by dewaxing in the centrifuge.
(4) Redistillation for recovery of naphtha, bright-stock and neutral oils.

The relation of these operations is clearly shown in Figs. 5, 6 and 7, Article II[1] of this series.

Dilution with Naphtha. Cylinder stocks are diluted with naphtha to give solutions containing 50 to 75 per cent of naphtha. The naphtha serves to lower the viscosity so that the material can be easily pumped and so that the oil can drain from the chilled petrolatum in the centrifuge operation. Without naphtha, the cylinder stock will solidify at temperatures of 40 to 80 deg. fahr., and the solid petrolatum will be so well dispersed through the material that the viscous oil cannot drain from the wax. The properties of the naphtha are not important except that the initial-boiling-point should be high so that losses by evaporation are small and the end-point should be low or the separation of the naphtha from the bright-stock by distillation will be difficult. In general the naphtha is a treated distillate having a boiling-range between 140 and 440 deg. fahrenheit. The naphtha is recovered during the complete cycle so that none is used except that which is lost by evaporation. A distillation curve of a bright-stock solution is shown in Fig. 12, Article IV of this series.[2]

The cylinder stock solution may be brought to the proper color either by filtration through Fuller's earth in percolation equipment or by the method of contact filtration. The contact method has found favor during the last few years. In this process the oil is mixed with finely-powdered clay and heated for a few minutes at 350 to 650 deg, fahr. in a pipe-still. The hot mixture is then filtered through a short percolation filter to remove most of the clay and finally through leaf-type filter presses to remove the suspended particles of fine clay. The subject of treating will be fully discussed in subsequent papers.

[1] "General Processing," *The Petroleum Engineer*, p. 39, December, 1933.
[2] *The Petroleum Engineer*, p. 44, February, 1934.

Chilling and Centrifuging. A more detailed idea of the chilling and dewaxing operations can be had from Fig. 20. The filtered solution is cooled slowly to about 20 deg. fahr. in three large chilling tanks shown in the upper part of the figure. These tanks or settlers are used intermittently, that is, while two of them are cooling, the chilled stock is being withdrawn from the third. After a temperature of 20 deg. fahr. is attained the chilling may be conducted more rapidly by means of small chillers, which are cooled by direct expansion of ammonia. The chillers are usually provided with revolving paddles by which the oil is circulated. The chillers are connected so that all or part of them may be used, depending upon the amount of stock that is available or the pour-point that is required. The petrolatum is separated from the oil by high-speed centrifuges. Warm water is circulated past each centrifuge as a carrying liquid for the petrolatum. Petrolatum is a sticky solid and it must be melted from the upper walls of the bowl and the outlet port by means of warm water.

The Sharples centrifuge will process about 35 bbl. per day of cylinder stock so that each centrifuge handles about 100 bbl. of solution per day. Better rates than this have been obtained with some stocks, but with other stocks the rate has been even lower. Some refiners have found that the centrifuges operate more satisfactorily if a part of the petrolatum is recirculated through the system, and others have blended a small amount of untreated cylinder stock with the solution. It appears that some of the high-boiling oils and coloring matter act as inhibitors to the crystallization of wax so that low pour-points are obtained.

The centrifuging properties of a stock are greatly dependent on the degree of fractionation that is obtained in the topping or vacuum system in which the cylinder stock is produced. Too much crystalline wax spoils the stock for centrifuging, but too much asphaltic or tarry material makes the treating operations expensive.

Rerunning Bright-Stock Solution. Until recently the redistillation of bright-stock solution for the recovery of naphtha and to produce a suitable grade of bright-stock, has been carried out in shell stills by the use of a large amount of steam. The new equipments that have been built for this purpose have been continuous pipestill and fractionator dis-

tillation equipment. The use of the pipestill and continuous processing has cut the steam that is required to less than half the amount required for shell-still processing.

Two types of pipestill equipments have been promoted; one a single-flash, single-tower system and the other a two-flash system. The single-flash system is similar to the system for pressed distillate, which is shown in Fig. 19, Article VII.[3] In fact, a single distillation unit may be designed to operate on either pressed distillate or bright-stock solution. One stock is processed for several weeks, while the other is accumulated in storage tanks and then the operating conditions are changed and the other stock is processed. In one instance a topping plant is being operated for about one week out of each month on bright-stock solution. It is claimed that only one hour is required to switch from one operation to the other.

The single-flash operation seems to be the better; the equipment is simple, a little less steam is required than for double-flash operation, the equipment is less expensive and it can be easily controlled and operated. If the general system shown in Fig. 19 were used to redistill bright-stock solution, the top product would be naphtha, the products from the side of the column would be gas oil and a neutral oil and the material from the bottom of the column would be bright-stock. Bright-stocks range in viscosity from 90 to 180 seconds at 210 deg. fahr., but the most common grade has a viscosity of 150. Because of this range, the operation may need to be changed from time to time and hence the neutral stock that is withdrawn as a side product will range from a few per cent of low viscosity neutral to even 12 per cent of 300 viscosity neutral, depending upon the viscosity of the bright-stock that is being produced.

Although single-flash operation is considered as better practice than double-flash operation I have chosen, as an illustration, to show a double-flash system in Fig. 21. The only advantage that is claimed for the double-flash system is the better fractionation that may be obtained by the reboiler effect of the second-flash. The solution is pumped through heat exchangers and into the first-flash coil of the pipestill. In this coil the oil need not be heated to more than about 500 deg. fahrenheit. The liquid that remains after the first-flash is pumped while hot into the second-flash coil of the pipestill and heated to a temperature not exceeding 720 deg. fahrenheit. This temperature is not high enough to cause the vaporization of all the neutral oil and hence steam must be admitted to the second-flash part of the tower. A second-flash vaporizer temperature that is higher than 680 deg. fahr. will usually cause the stock to be discolored. The steam and any naphtha vapor that may have arrived in the second-flash vaporizer, pass up the column, through the first-flash and into the overhead condensers. The steam is admitted at the bottom of the column so that it serves to strip the bright-stock to the proper flash-point as well as reduce the vaporizer temperature.

Solving Dewaxing Methods. The use of two dewaxing methods, namely, the wax press for wax distillate and the centrifuge for cylinder stock, has been a source of great expense to refiners. Many new methods of dewaxing, by which both the wax distillate and the cylinder stock can be handled in a single dewaxing operation, are being studied. Two general types of processes have been proposed; one by which the entire wax-bearing stock can be filtered through presses and the other in which the entire wax stock can be centrifuged.

The filter press methods either utilize a special solvent in which the wax is nearly insoluble or an aid to filtration in the form of a powdered solid that makes the wax cake more porous. Only one process, the use of trichlorethylene as a solvent, has been suggested for centrifuge dewaxing. The four most widely known new dewaxing processes are:

[3]*The Petroleum Engineer*, May, 1934.

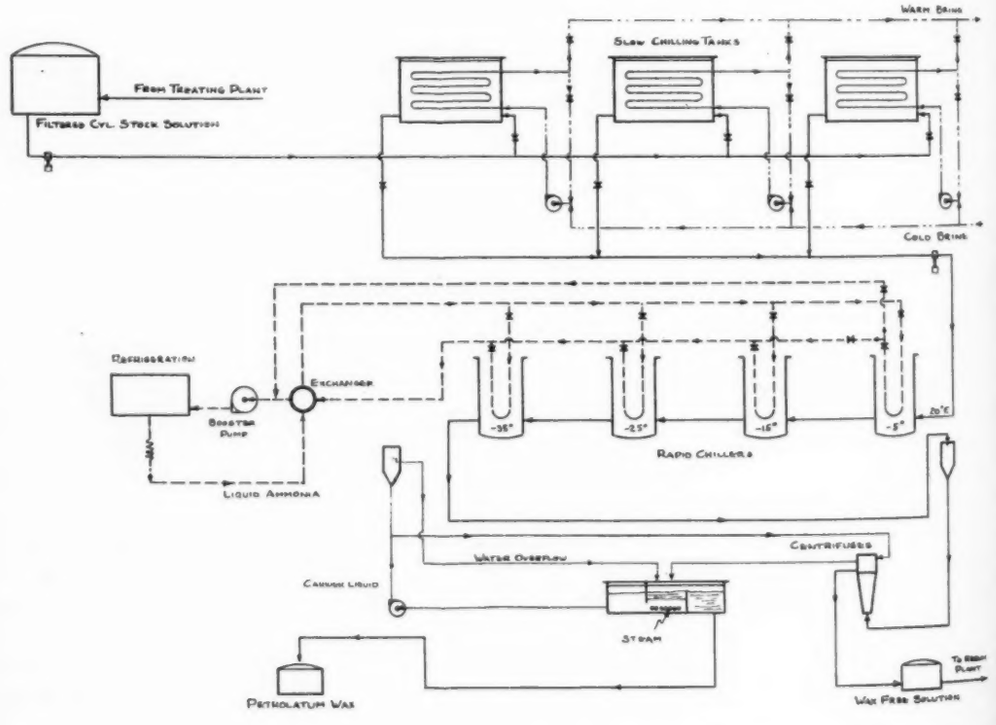


Fig. 20—Flow diagram of centrifuge dewaxing plant

(1) Filtration in propane solution.
(2) Filtration in benzol-acetone solution.
(3) Filtration with the use of filter-aid in naphtha solution.
(4) Centrifuging in trichlorethylene solution.

The outstanding features of the propane process are: the self-refrigeration of the solution by allowing the propane to vaporize; the cheapness of the solvent and the fact that it may be recovered in the regular natural gasoline absorption system; and the fact that the solution can be rapidly cooled and still produce a stock that can be easily filtered. By allowing about half of the solvent to evaporate, the temperature is reduced to about minus 40 deg. fahr., and the pour-point of the finished oil will be about zero deg. fahrenheit.

When using benzol-acetone as a solvent a range of stocks from 70 viscosity at 100 to 85 viscosity at 210 deg. fahr. can be successfully filtered. The separation of wax is so effective that the solution need not be cooled to more than about five degrees below the desired pour-point. The rate of filtration is much higher than in the normal wax-pressing method. The solvent is expensive but with an adequate vapor recovery system the process is economically feasible.

The filter-aid process of filtration, using naphtha as a solvent, has many possibilities. Materials such as "Hyflo-super-cel" and "White-speed-flow" are added to the wax solution. These materials act as a framework in the wax cake that makes the cake more rigid and at the same time more porous. The entire range of wax-bearing stocks have been dewaxed by this process. Although filter-aids have not been widely used with other solvents than naphtha, there is no reason why they should not be an advantage if used with any of the other solvent methods. However, filtration is usually rapid if special solvents are used and hence the advantages of using a filter-aid are not so important as when using naphtha.

The centrifuge process using trichlorethylene as a solvent is based on the selective solvent action of trichlorethylene and its high density. The wax is only slightly soluble in trichlorethylene and the increased density of the solution makes the centrifuge separation simpler. The solution is non-inflammable and it may be stored under water to prevent evaporation losses.

In most of the solvent dewaxing processes, closed leaf-type filter presses may be used. These can be automatically controlled without opening the press, the rate of filtration is somewhat higher than in frame-type presses and the oil may be more completely washed from the cake than in the ordinary wax press process. In general, the use of special solvents also removes a small amount of coloring matter and tar. It is possible that a combined solvent treating and solvent dewaxing process will soon be developed.

QUESTIONS

1. What is the reason for circulating warm water through the bowl of the centrifuge machine?
2. List the four main operations involved in producing bright-stock from cylinder stock.
3. Name three new dewaxing methods.
4. What is meant by the terms, single-flash and double-flash system?
5. What is the outstanding feature of the propane dewaxing method?

REFERENCES

1. Bell—Book "American Petroleum Refining," D. Van Nostrand Co.
2. Lederer & Zublin—"Manufacture of Low Pour-Point Oils," *Refiner and Natural Gasoline Mfr.*, p. 73, January, 1931.
3. Govers & Bryant—"Solvent Dewaxing of Oils with Benzol and Acetone," *Refiner and Natural Gasoline Mfr.*, p. 222, June, 1933.
4. Gee—"Filtering . . . with Filter Aid," *Refiner and Natural Gasoline Mfr.*, p. 238, June, 1933.
5. Bahlke et al—"Dewaxing . . . Propane . . . Self-Refrigeration," *Refiner and Natural Gasoline Mfr.*, p. 229, June, 1933.
6. Pester—"Centrifuge Dewaxing . . .," *Oil and Gas Journal*, p. 52, May 25, 1933.
7. Staley—". . . Imported Processing Methods," *The Petroleum Engineer*, p. 20, Mid-Year, 1933.
8. "Will Spend Five Million Dollars for Solvent Extraction and Dewaxing . . ." *Oil and Gas Journal*, p. 44, March 29, 1934.

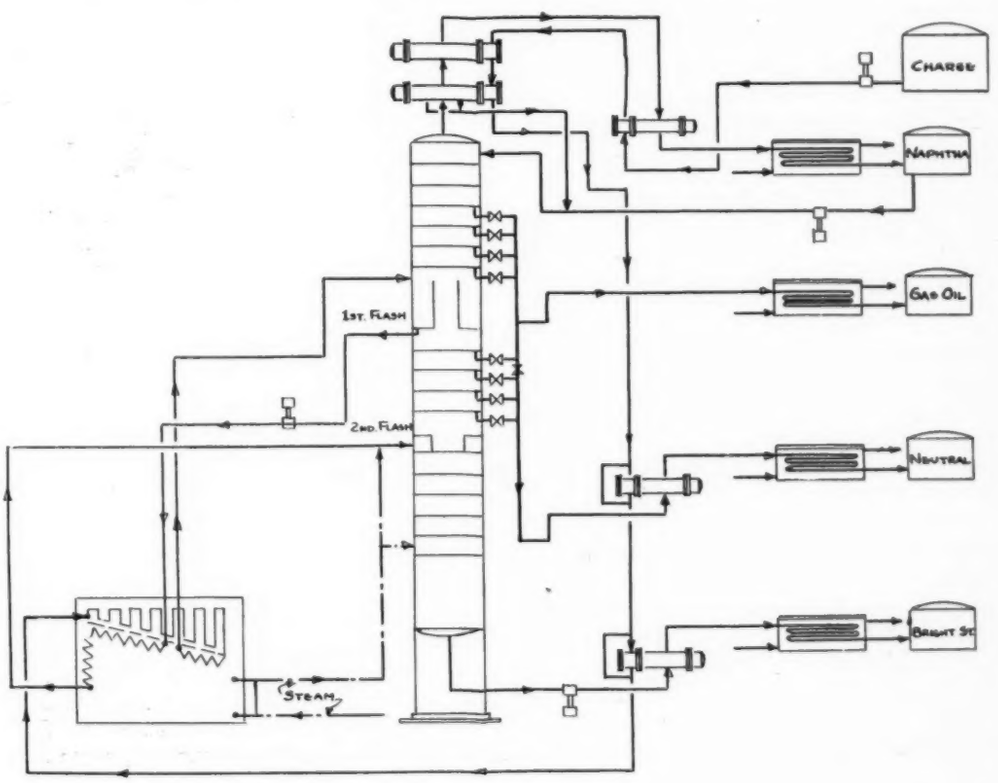


Fig. 21 — Double-flash bright-stock solution rerun plant

Elements of Applied Production

By K. C. SCLATER

Article 8

EQUIPMENT AND OPERATION OF OIL WELLS (Continued)

Gas-Lift Wells

CONTINUOUS FLOW. There are two general methods of producing wells by the gas-lift: (1) by continuous flow; (2) by intermittent flow. The former is known as the straight gas-lift and is the method usually adopted when a well that has been flowing naturally begins to "head."

Putting a well on straight gas-lift usually does not involve any change of equipment if the well has been flowing naturally through the tubing. A straight gas-lift well is in all respects similar in operation to that of a naturally flowing well, except that high-pressure gas has to be supplied from a source outside the well itself. It may be flowed through tubing or through the annular space between the tubing and the casing; the input gas being injected down the casing or down the tubing accordingly. Whether a well should be flowed through the casing or through the tubing will depend on the well conditions. If a satisfactory rate of flow can be maintained, the method giving the lowest output gas-oil ratio will be the one most suitable. Where it is not desired to make any change in the tubing when putting a well on straight gas-lift, whether the well will be flowed through the tubing or casing will usually be governed by the gas-oil ratio.

An important consideration that may enter is the availability of an adequate supply of high-pressure gas at low cost. High-pressure input gas may be available from the traps of near-by high-pressure wells or from a gasoline plant. If compressor equipment is installed especially for gas-lift, tubing flow strings may have to be designed that will give the most efficient operation.

If water is being produced with the oil emulsification may occur. Treating emulsions may be an expensive item and one that must be considered in straight gas-lift flow. Water in a gas-lift well can be controlled by holding back pressure at the surface. This is done by means of an adjustable choke or flow bean in the flow line. The back pressure on the sand may also be varied by manipulating the pressure and volume of input gas to the well.

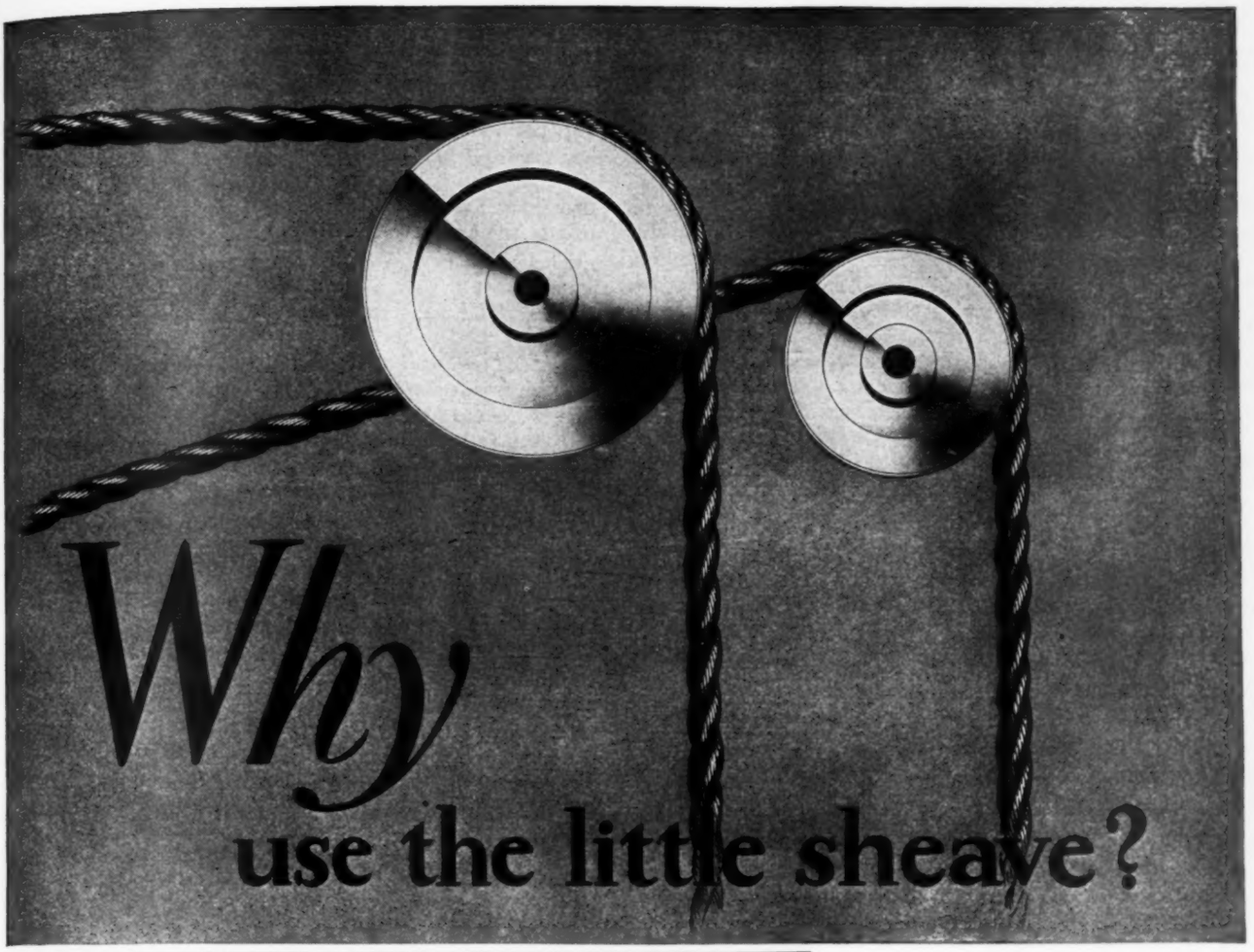
There is no limit to the size of well in which the straight gas-lift may be used. The tubing string may be straight or tapered. With curtailment in effect, straight gas-lift through tubing of 2-in. or larger diameter is seldom required. Where these larger sizes of tubing are used it may not be necessary to produce a well for more than two or three hours daily. The well would then fall into the class of intermittent flowing wells produced by manual control. Once the amount of gas required in a straight gas-lift well is determined there is little trouble with operation. It is operated like a well on natural flow.

Straight gas-lift was first employed for fairly large wells. In recent years, however, straight gas-lift has been successfully adapted for use in small wells. If the submergence (or bottom-hole pressure) is sufficient, a well can be flowed by straight gas-lift with reasonable efficiency.

The amount of gas required to flow a well will depend on the depth and the character and quantity of the fluid to be lifted. Figures for the Seminole field, compiled from the results obtained in a large number of flowing wells in the field,[41] show that the amount required to flow wells varies from 1000 cu. ft. of gas per bbl. of oil at the rate of 4800 bbl. per day to 4000 cu. ft. at 200 bbl. per day and 1700 cu. ft. at about 65 bbl. per day from a depth of 4000 feet. These figures are applicable only to the Seminole field or to fields of the same depth and where the density, temperature and viscosity of the oil and the bottom-hole pressures are similar. These items enumerated, namely, density, temperature and viscosity of the oil and bottom-hole pressure, are of importance in influencing the amount of gas required to lift the oil in any well regardless of whether it is produced by natural flow or by gas-lift. It is necessary to control the input gas at the surface to some predetermined quantity in order to get the best results. Such determinations are now based chiefly on considerations such as the diameter and length of the flow column.

In gas-lift we are concerned with the amount of gas energy required to lift a barrel of oil. Besides the gas dissolved in the oil there may also be free gas in the sand with the oil, but it may not contain sufficient energy to flow the well. The make-up gas required must be estimated.

Energy, for our purposes here, is best expressed in foot-pounds (ft-lb.). The minimum energy in ft-lb. required to lift the oil to the surface is equal to the weight of the oil multiplied by the distance in feet through which the oil is lifted. Thus, consider one barrel of oil of 36.5 deg. A.P.I. gravity raised 1000 feet. Oil of 36.5 deg. A.P.I. gravity weighs approximately seven lb. per U.S. gallon or 294 (42X7)



Know your Ropes

...This is a helpful hint, how to make wire rope last longer. Subsequent Wickwire Spencer advertisements in this publication will give other dollar saving information. Tell us about your rope problem and we will give you the answer.

There is a minimum sheave diameter for every size of rope. The use of any smaller sheave will materially reduce the life of the rope. Too small sheaves impose unnecessary bending and unbending causing premature fatigue of wires on the crown strand. Too small sheaves also distort the symmetrical round shape of the rope which causes an uneven distribution of the applied load with the overstraining of some of its parts.

We will gladly send you a table that gives the safe ratios between the various sheave diameters and rope diameters. Send for it. Its use will make your rope live longer.

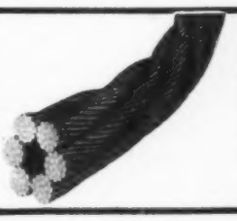
o

WICKWIRE SPENCER STEEL COMPANY, 41 East 42nd Street, New York City; Buffalo, Chicago, Detroit, Philadelphia, Tulsa, Chattanooga, Worcester; *Pacific Coast Headquarters:* San Francisco; *Warehouses:* Portland, Los Angeles, Seattle. *Export Sales Dept.,* New York City.

WIRE ROPE
by Wickwire Spencer

BOTH...STANDARD LAY AND WISSCOLAY PREFORMED.

Wickwire Spencer manufactures all sizes and types of Wire Rope in standard lays and preformed. Wisscolay preformed wire rope will often solve a wire rope application difficulty. Ask our engineers where and when it should be used. Send for a free WIRE ROPE BOOK. It will prove of great value.



lb. per barrel. The minimum energy required, neglecting friction and slippage losses, would be:

$$1000 \times 294 = 294{,}000 \text{ ft-lb.}$$

Gas under pressure has energy. Each cu. ft. of gas can be made to do useful work during expansion. The amount of work it is capable of doing will depend on its pressure and temperature before and after expansion. We may estimate with sufficient accuracy the amount of work the gas is capable of doing if we assume it is a perfect gas and that expansion takes place at constant temperature, that is, isothermally, which for all practical purposes we may assume it does in an oil well. In the following table is shown the amount of work in ft-lb. performed by a perfect gas in expanding at constant temperature from a given pressure to atmospheric pressure.

Pressure of Gas Before Expansion to Atmospheric Pressure	Work Done During Expansion at Constant Temperature
100 lb. per sq. in. (gauge)	4329 ft-lb.
200 lb. per sq. in. (gauge)	5676 ft-lb.
300 lb. per sq. in. (gauge)	6486 ft-lb.
400 lb. per sq. in. (gauge)	7069 ft-lb.
500 lb. per sq. in. (gauge)	7527 ft-lb.
600 lb. per sq. in. (gauge)	7902 ft-lb.
700 lb. per sq. in. (gauge)	8222 ft-lb.
800 lb. per sq. in. (gauge)	8499 ft-lb.
900 lb. per sq. in. (gauge)	8744 ft-lb.
1000 lb. per sq. in. (gauge)	8964 ft-lb.
2000 lb. per sq. in. (gauge)	10,414 ft-lb.
3000 lb. per sq. in. (gauge)	11,294 ft-lb.

Assuming an initial pressure of 300 lb. per sq. in. gauge before expansion and that no losses occurred during expansion the number of cu. ft. of gas that would be required to lift one bbl. of oil of 36.5 deg. gravity A.P.I. to a height of 1000 ft. would be:

$$\frac{1000 \times 294}{6486} = 45.3 \text{ cu. ft.}$$

It was pointed out in Article 7 that the efficiency of the gas-lift is roughly equal to the percentage submergence. If the submergence were 20 per cent the estimated number of cu. ft. gas required under actual operating conditions would be:

$$\frac{45.3}{.20} = 276 \text{ cu. ft. per bbl.}$$

This figure could probably be improved upon by good operation at the well. This is the approximate volume of gas required regardless of whether or not the gas for lifting accompanies the oil as in a naturally flowing well or has to be supplied from an outside source as in a gas-lift well. If the bottom-hole pressure is known and also the amount of gas associated with the oil, an estimate of the quantity of make-up gas for producing the well by straight gas-lift can be closely estimated.

On larger wells it is seldom that the gas is reduced to atmospheric between the bottom of the hole and the surface. The ft-lb. of work done by the gas in expanding between pressures higher than atmospheric has then to be estimated. From this quantity the number of cu. ft. of gas required to raise any quantity of oil from any depth under known conditions may then be estimated.

Intermittent Flow. When the bottom-hole pressure and the production of the well make it no longer feasible to produce by straight gas-lift, intermittent flow methods may be used. This method of producing wells has come into wide use in recent years as it is well adapted to the operation of wells on curtailed production.

It has been generally observed from field experience that a lower gas-oil ratio is obtained with intermittent flow than with straight gas-lift. Walker[42] also makes the observation that greater benefit will be derived from intermittent injection in the later life than in the early life of a well.

There are now two generally recognized types of intermittent flow: (1) that obtained by the use of a displacement chamber, and (2) that obtained without the use of a displacement chamber. When a displacement chamber is used, two strings of tubing are used. The lower end of the larger string is swedged out to form a chamber, which is equipped with a standing valve on the bottom.[43] In wells of very low bottom-hole pressure the displacement chamber has an important advantage in that the pressure of the input gas is kept off the face of the sand.

There is also less tendency for emulsions to form if water is present. Instead of the input gas lifting the oil by being disseminated through it as in the straight gas-lift, the gas acts more like a piston, pushing the oil out in the form of a slug and the flow produced is called the "slug" or "piston" type of flow.

In intermittent flow, gas under pressure is injected into the well at regular intervals. For controlling the interval, intermitters are used. The control of the interval can also be done manually. Where a group of wells are to be produced at frequent intervals manual control is not feasible.

There are several intermitters on the market. Among those most widely used and best known are:

1. The Jat intermitter.
2. The National Tank Company intermitter.
3. The Maxi-flo intermitter.

In addition to these there are others in use that embody the features of the intermitter and the displacement chamber.

One of these is the Clark Bros. Rubel displacement pump, which by means of valves controlled by fluid level, can make a well produce intermittently by displacement flow.[44]

Another of these pumps that falls into the automatic intermitter class and also gives a "slug" type of flow in gas-lift wells is the Hughes plunger lift.[45] This is one of the most recently developed pumps and one that is rapidly increasing in use for flowing deep wells.

QUESTIONS

1. How can water be controlled in a well produced by straight gas-lift?
2. To what type of wells is straight gas-lift best adapted?
3. What are the important factors influencing the volume of gas required for lifting?
4. How would you estimate the volume of input gas required in wells to be produced by gas-lift?
5. What are the advantages of a displacement chamber in a well produced by intermittent gas-lift?

REFERENCES

41"Modern Developments in the Raising of Oil," by S. F. Shaw—World Petroleum Congress, London, 1933, Proceedings, Vol. 2.

42"Intermittent Injection of Gas in Gas-Lift Installations," by M. Walker—A.I.M.E. Petroleum Development and Technology, 1928-29.

43"Wells Produced by Gas-Lift Yield Encouraging Results," by K. C. Sclater—*The Petroleum Engineer*, September, 1930.

44"Automatic Flow Device Pumps Small Wells Automatically"—*Oil Field Engineering*, March, 1929.

45"Simple Principles Adopted to Pump With Free Traveling Plunger that is Automatic in Operation," by H. W. Fletcher—*The Petroleum Engineer*, March, 1932.

Petroleum Production Technology . . . *from exploration to the finishing of wells*

THIS is a review and reference work of fundamentals, problems, methods and equipment—for all interested in a broad, practical understanding of petroleum production — covering those practices connected with the construction of wells, ready to produce oil.

New Second Edition

Petroleum Production Engineering
OIL FIELD DEVELOPMENT

By LESTER C. UREN
Professor of Petroleum Engineering, University of California

531 pages, 6 x 9 • 258 illustrations

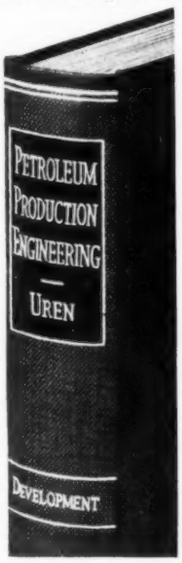
$5.00

This is the first book of a two-volume edition, revised and enlarged to cover the far-reaching advances of recent years in this field. This book, complete in itself, gives a practical treatment of every phase of petroleum production engineering up to the point at which the wells are ready to produce. It introduces the fundamentals of field location and covers thoroughly the problems, methods and equipment of oil field development and modern deep-well drilling.

Every process and method of any consequence is fully explained and complete descriptions are given with illustrations of all commonly used oil field equipment, tools and appliances. In assembling this book an effort has been made to develop a well-balanced treatment that does not unduly stress some topics nor slight others. It has been prepared particularly for those seeking a broad view and a thorough understanding of field development in all its phases, rather than specialized treatment of any one branch of the work. The author has drawn both on his own experience and on the literature for information representative of all that is new, practical and effective in this rapidly-advancing field.

Chapter Headings

1. Properties, Occurrence and Associations of Petroleum.
2. Petroleum Exploration Methods.
3. Acquisition of Title to Oil Lands.
4. Developing the Field.
5. Drilling Equipment and Methods; General Features.
6. Churn Drilling Equipment and Methods.
7. Rotary Drilling Equipment and Methods.
8. Casing, Casing Appliances and Casing Methods.
9. Fishing Tools and Methods.
10. Oil-field Hydrology; Exclusion of Water from Wells.
11. Finishing the Well.
12. Well Records.



Order from

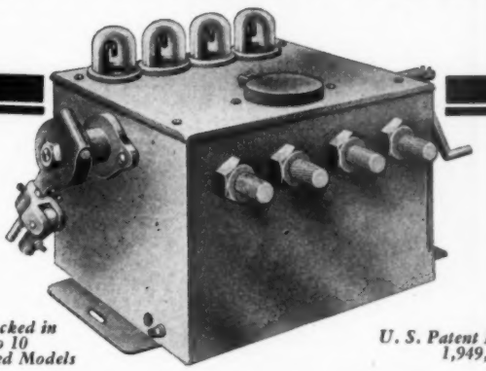
The PETROLEUM ENGINEER PUBLISHING COMPANY

Tower Petroleum Building DALLAS, TEXAS

NOW

. . . a Lubricator that Lubricates Against

3,000 Pound Pressure!



Stocked in 1 to 10 Feed Models

U. S. Patent No. 1,949,272

. . . and Does it Continuously Under Oil Field Conditions

"Standard" delivers the goods — guarantees to lubricate at pressures up to 3,000 pounds in heaviest duty drilling and compressor work—because each pumping unit is built to do just that and to keep on doing it. And when replacement of any part does finally become necessary the standardized and interchangeable parts, new or old, fit quickly and easily into place without stopping the other pumping units in a reservoir. Each pumping unit adjusts at the touch of a finger to pump the precise amount of lubricant required and is removable without using tools for inspection, cleaning, etc., while in operation.

Standardize with "Standard" Lubricators

STANDARD
FORCE and SIGHT FEED
LUBRICATORS

Equipped with roller-bearing clutch instead of Ratchet Wheel, Pawl and Pawl Springs—and with Bronze Oilless Bearings instead of Stuffing Boxes—and with die-cast Pumping Unit; stainless steel plungers; hardened, precision-fit stainless steel valves (no balls)—"Standard" lubricators offer positive lubrication at lowest cost over a virtually endless service life.

Sold by Leading Oil Field Supply Houses

AMERICAN LUBRICATOR COMPANY,
First National Bank Bldg., Dallas, Texas.

Gentlemen: Send complete facts about Standard Force and Sight Feed Lubricators to

Name .....

Address .....

.....

Economical Operation:

This Reason alone Warrants Installing AXELSON Pumps and Sucker Rods

AXELSON MANUFACTURING CO.
P. O. Box 710, Vernon Station, Los Angeles

St. Louis 50 Church St., New York Tulsa

Mid-Continent and Eastern Distributor:
Frick-Reid Supply Corporation

Rocky Mountain Distributor:
Great Northern Tool & Supply Company

The Petroleum Engineer Publishing Company,
P. O. Box 1589, Dallas, Texas.

Date .....

Enter my subscription to The Petroleum Engineer from above date for one year, to be sent to me at address below, for which I hereby hand you (check) (cash) in the amount of $1.00 ($1.65 in Canada).

Name .....

Company .....

Title .....

(To avoid delay, please do not fail to state your title.)

Street of Box No. .....

City ..... State .....

Country .....

Hartford Electric Light Co. Wins Charles A. Coffin Foundation Award

To the Hartford Electric Light Company, one of the pioneer electric utilities of America, goes the annual award for 1933 of the Charles A. Coffin Foundation, established by the General Electric Company. The presentation of the award was made June 6 at Atlantic City to Samuel Ferguson, president of the winning company, during the annual convention of the Edison Electric Institute.

The award comprises the Charles A. Coffin gold medal, a certificate, and a check for $1,000 to be deposited in the treasury of the utility's Employes' Welfare Association. Determination of the winner of the award was made by a committee of judges consisting of George B. Cortelyou, president of the Edison Electric Institute; Dr. Karl T. Compton, president of Massachusetts Institute of Technology; and Frank W. Smith, chairman of the prize award committee of the Edison Electric Institute.

The record of the Hartford Electric Light Company for 1933, upon which the award is based, is declared to be most impressive. In a depression year this company reduced the rates to its customers, at the same time improving the quality of its service; maintained its full force of employes at the 1929 level and without reductions in pay; paid full dividends to its stockholders, setting aside a moderate surplus, but larger than the previous year, and maintained a city-wide good will with its public.

Conspicuous in the methods by which this good will was fostered was the company's "credit certificate" plan, under which customers who were unable to pay their electric service bills were permitted to sign a form certifying that they would pay the bills as soon as financially able to do so. Reductions in rates during the year were made possible by using as a cushion a "customer dividend" plan, in effect during previous years since 1925. This dividend was not paid in 1933, but its withdrawal enabled the company to carry out the lower rate policy, as well as to maintain its previous level of wages to its employes.

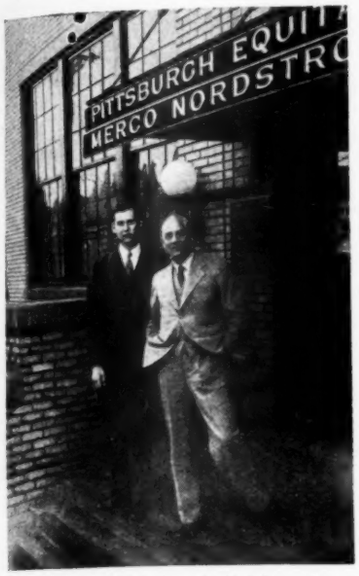
In other respects the company also was regarded by the award committee as extremely progressive. It introduced a plan for promoting electric cooking through a year's free trial of electric ranges, preceded by an offer of 500 ranges at a weekly rental. It sponsored promotional electric rates, the principle underlying which was explained by its president, Samuel Ferguson, at meetings of customers. It promoted the all-electric home idea, with the aid of the electric kitchen exhibit of the General Electric Company, until at the end of the year there were 750 all-electric homes in the company's territory. Similar coöperative and progressive activities were applied to the rural districts in the farm electrification movement.

As factors contributing, on the technical and engineering side, to its accomplishments in 1933, the company listed 16 pioneer accomplishments in which it led the electric utility industry of the country. These included the first 3-phase a. c. transmission, the first use of a storage battery to provide reserve electricity for its power system, the first use of steam turbines to drive its generators, the first experimental and first commercial installation of General Electric mercury vapor turbines, and first use of aluminum for transmission conductors.

The company has made intensive efforts over a period of years to insure maximum accuracy of its meters, has had a steadily declining ratio of lost-time accidents, and established in 1925 the Connecticut Valley Power Exchange for the operation of interconnection when needed, this plan resulting in a net saving during 1933 to the Hartford Electric Light Company of $69,700. Since the exchange was formed the total savings to the Hartford company have been $619,000.

English Visitors at Valve and Meter Factories

Kenneth M. Leach, of the Audley Engineering Company, Ltd, Newport, Shropshire, England, who has been in the United States for the past three months visiting the factories of the Merco Nordstrom Valve Company and the Pittsburgh Equitable Meter Company, Pittsburgh, Pa., recently was joined by his father, R. W. Leach, Chairman of the Board of Audley.



Kenneth M. Leach (left) and R. W. Leach

The Audley Engineering Company, Ltd., is closely affiliated with the Merco Nordstrom Valve Company and is licensed under the Nordstrom Patents to manufacture "Audco" Lubricated Plug Valves for Europe and Asia. Messrs. Leach showed great interest in American methods of manufacture and contemplate the additions of several items to their present "Audco" line. The Senior Mr. Leach stated that "Business with Audley in 1933 reached a new peak for all times, and we anticipate an even greater record during this year." During their stay in Pittsburgh, they were house guests of Mr. and Mrs. W. F. Rockwell.

John T. Dillon, Sr., a Pioneer in Industry, Passes Away

Throughout the entire oil industry grief is being expressed at the death of a pioneer, John T. Dillon, Sr., who passed away in New York City early this month at the age of 74. Until recent years Mr. Dillon was actively affiliated with a number of manufacturing and financial concerns, all directly connected with the oil business. One of the first manufacturing concerns to make equipment for the oil industry was the Titusville Forge Company, founded by Mr. Dillon at Titusville, Pennsylvania. Later he instituted the Titusville Iron Works Company and was its active head until only a few years ago, when he was succeeded by his son, John T. Dillon, Jr. Other companies with which he was identified are Warren Axe & Tool Company, Warren, Pa., of which he was chairman of the board; Lake Erie Engineering Corporation of Buffalo, of which he was president; Marine Trust Company of Buffalo, of which he was a director; and Struthers-Wells-Titusville Corporation, of which he was formerly president.

Mr. Dillon is survived by his widow and nine children. Among the boys who are well known in the oil industry are J. T. Dillon, Jr., president of Struthers-Wells-Titusville Corporation and Titusville Iron Works Company; Thomas Dillon, vice-president of Struthers-Wells-Titusville Corporation; and R. E. Dillon, vice-president and general manager of the Lake Erie Engineering Corporation.

John T. Dillon, Sr., enjoyed the friendship of scores of men in the petroleum and other industries who will remember him for his fine personality, his strict honesty and integrity.

B-M-W PRODUCTS for pumping wells
The KEY to LOWER LIFTING COSTS
CORRECTLY DESIGNED · · ECONOMICALLY PRODUCED
REASONABLY PRICED

TRIAD CUPS . . . .

Just the best composition cup made . . performance proves it.

A B-M-W Product

BRADFORD MOTOR WORKS INC.
OIL WELL SUPPLIES
BRADFORD, PA. TULSA, OKLA.
EXPORT OFFICE – 30 CHURCH ST. – NEW YORK CITY

Look for the Arm-and-Hammer Seal
ARMSTRONG BROS.
CHAIN TONGS

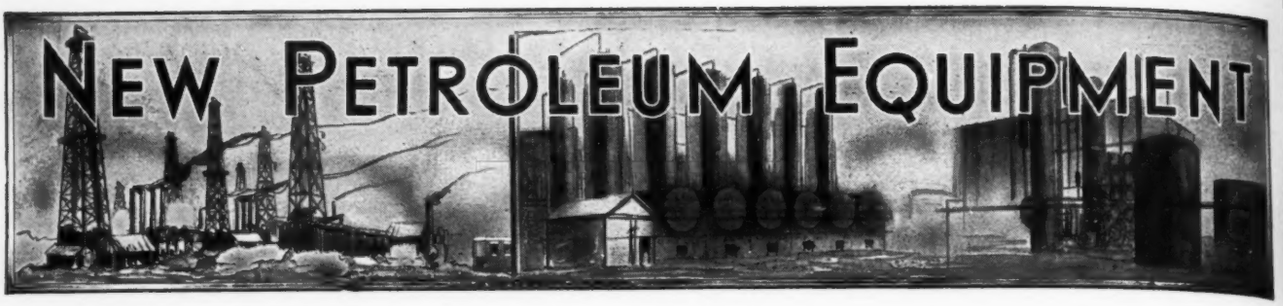
Jaws drop forged from special steel, heat treated, hardened, tempered and tested. *Handles* forged from high carbon steel have both stiffness and "spring." *Chains* have proven strength—are proof-tested to 2/3 catalog strength (3,600 to 40,000 lbs.). *Design improvements:* jaws have increased bearing on bar and forged-in chain guides, large steel bolt, drop forged shackle.

Write for Cat. P-10

Better
PIPE TOOLS
The most complete line made and each an *improved* tool.
Solid Dies and Stocks
Adjustable Dies and Stocks
Hinged Pipe Vises
Chain Pipe Vises
Pipe Vise Saddle
Pipe Cutters
Knife Blade Cutter Wheels
Patented Pipe Wrench

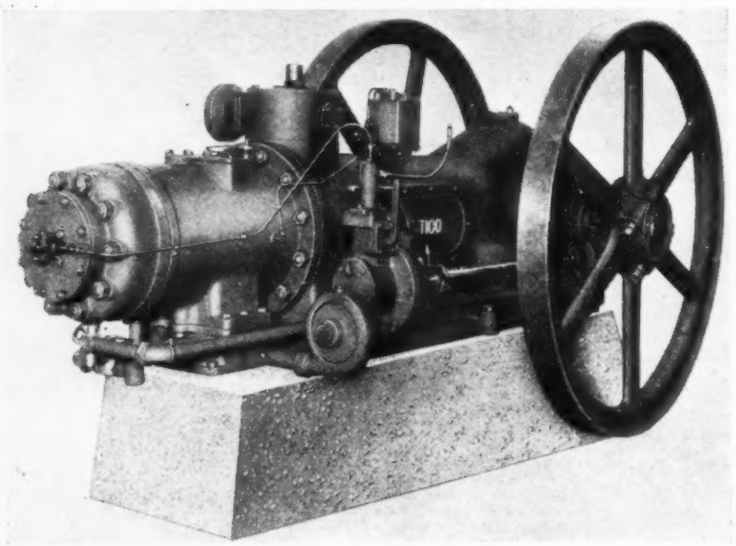
Armstrong Bros. Tool Co.
"The Tool Holder People"
331 N. Francisco Av., Chicago, U.S.A.

Mid-Cont. Rep., EARL WADDEL
Fair Building, Fort Worth, Texas



Tico Diesel Convertible Oil and Gas Engine

DRILLERS in East Texas and other localities where the dual-operated engine is required will be interested in the development of the new Tico Type "C" 12½-in. by 16-in. convertible gas and oil engine. This engine, manufactured by the Titusville Iron Works Company, Titusville, Pa., can be changed from gas- to oil-fired or vice versa in two hours to meet the varying fuel requirements of different localities, and has been developed to meet the heaviest demands of swabbing, drilling and deep well pumping. A feature of its design is the full Diesel engine construction which makes possible efficient and economical operation with a good grade of crude oil.



Fuel injector and pump are controlled by a special flyball governor that not only regulates the speed of the engine, but also delivers the exact amount of fuel to the cylinder at varying loads. This is governed by a regulating valve, all surplus oil rejected by which is piped to a small reservoir or recovery tank.

According to the manufacturers, considerable weight and strength have been added throughout, the main frame alone being exceptionally rugged to withstand without vibration any stress likely to be imposed upon it at high speeds.

The cylinder has a long apron projecting into the frame, secured with a heavy flange and twelve 1¼-in. alloy steel bolts. The piston rod is 2½ in. in diameter and is equipped with a double seal metallic piston rod packing box of the latest Garlock design, serving as an oil wiper and vacuum seal.

The shaft diameters at bearings are 6-in. and are equipped with four heavy duty Timken roller bearings. The crank pin diameter is 6½ in. and that of the cross pin four inches.

A special air valve is located on top of the main frame, having four ground steel discs 1/16 in. thick with 1/16 in. lift and large area. The valve seat and keeper are made of accurately machined alloy cast steel.

The speed of the engine can be controlled either by hand adjustment or remote manipulation from the derrick with a speed range of 160 to 350 r.p.m.

Heggem Rotary Drilling Valve

A RECENT engineering achievement of note is the development by the Oil Well Improvements Company, Tulsa, Oklahoma, of their Heggem Rotary Drilling Valve. This valve (shown in the illustration) involves the principle of the lever for opening and closing. The action is a lifting of the valve off the seat and then moving it to one side of the opening. The Heggem Rotary Drilling Valve was designed for high pressures, high temperatures and corrosive fluids. It consists of a rotary core mounted on a journal within the valve-body, and has a valve-plate mounted on a lever, one end of which is fulcrumed in the valve core and the other connected to an eccentric carried on the valve-stem. To operate, the valve stem is turned, carrying the valve core with it until the valve-plate is positioned directly opposite the seat. Then the core ceases to turn and further movement of the valve-stem, acting through the eccentric, forces the valve-plate out against the seat. To open, the valve-stem is turned to the left, the valve-plate being withdrawn from its seat and pulled into the valve-core, which is then rotated until the opening through the core lines up with the inlet and outlet openings of the valve-body. A 7-in. valve on which there is 400 lb. pressure can be opened by one man in 35 seconds, the manufacturers state.

Guiberson Diesel Engines for Oil Field Service

THE Guiberson Corporation, Dallas, Texas, originators and manufacturers of the tubing catcher, flexible-cup swab, tool joint, and other oil field specialties now in world-wide use, has perfected and is introducing a line of Diesel engines for trucks and busses and for oil well pumping and other industrial power requirements.

The new line of industrial Diesel engines has been an outgrowth of the company's success with its Diesel aircraft engine. The special patented fea-

ture of the Guiberson engines is the synchronization of fuel supply, timing, and air supply so that all are controlled by one throttle and proper proportions and relations of each of these elements is automatically assured at all speeds.

This feature promotes the smooth, clean, efficient and economical operation which is characteristic of these engines.

The engines have been perfected in every detail, during several years of experimental work, the manufacturers state. A 7½-ton truck powered with a Guiberson truck engine has been driven all over the United States and has performed satisfactorily under the most gruelling road tests.

On road tests the maintenance cost has been very low. Engineers attribute this fact to simplicity of construction, fewer parts, best materials, and experienced workmanship used in the building.

The speed range is wide and is due to an extreme flexibility which permits exceptional pick-up. At any speed there is a lack of detonation due to a new Guiberson system of muffling.

A feature of design is lightness. Experienced first in airplane Diesel engines, Guiberson has incorporated this feature into their truck, industrial and marine models. Through simplicity of design and the use of light materials, industrial engines, the heaviest type of Diesel, weigh less than 38 lb. to the horsepower unit.

Other new features are: a low maximum cylinder pressure, smokeless, clean exhaust at any speed or load, an easy starting ignition system which functions by heat generated by compression, and a full automatic lubricating system.

An idea of the remarkably low operating cost may be gained from the fact that the Guiberson Company sent a 7½-ton truck loaded with equipment to be shown at the International Petroleum Exposition in Tulsa, Oklahoma, recently from their factory in Dallas, Texas, a distance of over 300 miles, for a fuel operating cost of $1.75.

Annular Steam Jet Pump

FOR removing and reclaiming oil sludge an efficient Annular Steam Jet Pump, styled the ArmEng, has been placed on the market by Sludge Pumping, Inc., Pier 18, North River New York City. It is a small pump, being 18 in. long, 5 in. in diameter and weighing 23 pounds. The pump is portable, has no moving parts and will operate on steam pressure as low as 65 lb. at the pump, but the higher the pressure the greater the pumping rate. To operate, the suction intake is dipped into the sludge which is sucked into the pump and forced through the open discharge hose into the receptacle. The sludge, being subjected to contact with a terrific steam velocity, is broken up into its original oily state, in which it is discharged from the hose. Thus it may again be used as a plant fuel.

G. H. WALLACE

G. H. "Doc" Wallace, for the past 14 years works manager for one of the countrys' largest Diesel engine manufacturers, has been appointed sales manager of the Guiberson Diesel Engine Company and is beginning the formation of a national selling organization. Allen Guiberson is works manager of the company.

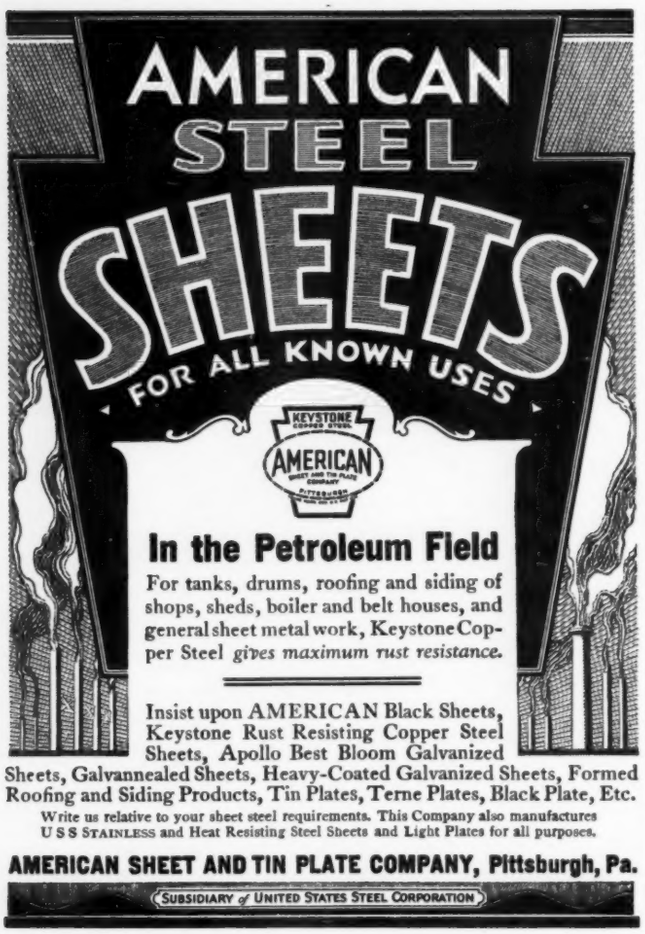
New Unit for Treating Emulsions

AFTER EXTENSIVE scientific investigation, the National Radiator Corporation, Johnstown, Pa., has announced the development of a new heater for demulsifying petroleum. A large oil company requested the National Radiator Corporation to construct a gas-fired heater that would be generally adaptable to removing water from oil at any well. Consequently a field study was made that revealed the fact that, at some wells, it was necessary actually to boil the water out of the oil because the emulsion was so difficult to break, while, at other wells, the emulsion broke very easily at temperatures of about 130 deg. fahrenheit. Occasionally it was necessary to pass the oil through a heater, while in other instances, emulsions could be broken by bubbling the oil through warm salt water. The production of the wells, of course, varied over wide limits.

The National Radiator Corporation engineering and research specialists concluded that, to meet practical requirements: (1) A demulsifying heater must be so designed that it can be assembled and knocked down easily in the field and all its parts must be light enough to be readily moved; (2) its throughput must be easily increased at the will of the operator; (3) it must be efficient on widely different methods of removing water, whether hot oil or hot water is used; (4) it must consist of a very limited number of castings.

It was found possible, after thorough experimental work, to incorporate all the above mentioned features in a heater that has the necessary highly efficient heat transfer, and that operates on waste gas produced by the wells, the National Radiator Corporation states. It consists of four types of castings, left and right end sections, a center section and a spacer bar. With these four castings, it is possible to set up quickly a heater of any desired size by merely adding more center sections. The sections are held together by machined cast iron nipples and heavy bolts, making an oil-tight joint. The entire heater can be assembled in a few hours.

This new heater has already been used with success in several systems of breaking emulsions, its manufacturers state. It has been fully described in a report issued by the National Radiator Corporation, copies of which are available upon request.


AMERICAN
STEEL
SHEETS
FOR ALL KNOWN USES
KEYSTONE COPPER STEEL
AMERICAN
In the Petroleum Field
For tanks, drums, roofing and siding of shops, sheds, boiler and belt houses, and general sheet metal work, Keystone Copper Steel gives maximum rust resistance.
Insist upon AMERICAN Black Sheets, Keystone Rust Resisting Copper Steel Sheets, Apollo Best Bloom Galvanized Sheets, Galvannealed Sheets, Heavy-Coated Galvanized Sheets, Formed Roofing and Siding Products, Tin Plates, Terne Plates, Black Plate, Etc.
Write us relative to your sheet steel requirements. This Company also manufactures U S S STAINLESS and Heat Resisting Steel Sheets and Light Plates for all purposes.
AMERICAN SHEET AND TIN PLATE COMPANY, Pittsburgh, Pa.
SUBSIDIARY of UNITED STATES STEEL CORPORATION

HOTEL BILTMORE
. . . in Oklahoma City, combines all the features of the modern metropolitan hotel at its best. All rooms have three-channel radio and every other possible convenience.
You'll find the food and service in both the Main Restaurant and Coffee Shop in keeping with Hotel Biltmore standards. The Hotel's downtown location makes theatres and shops easily available.
Room rates start at $2.50.
HOTEL
BILTMORE
OKLAHOMA CITY
$2.50 up
James C. Barrett . . . Managing Director

General Electric Company Elects New Vice-Presidents

Five vice-presidents and one commercial vice-president were elected by the board of directors of the General Electric Company at the meeting on May 25 in New York City.

J. E. Kewley, of Cleveland, Ohio, was e'ected a vice-president in general charge of the incandescent lamp department; R. C. Muir, of Schenectady, New York, vice-president in charge of the engineering department; C. E. Tullar, of Schenectady, vice-president in charge of the patent department; E. O. Shreve, of Schenectady, vice-president in association with Vice-President J. G. Barry, in the commercial activities of the apparatus and supply business of the company; H. L. Andrews, of Erie, Pa., vice-president in charge of the activities connected with the electrification of steam railroads and such other duties as may be assigned to him by the president; W. O. Batchelder, of Chicago, Ill., a commercial vice-president in charge of the commercial activities of the Chicago district.

T. W. Frech asked to be relieved of his responsibility as vice-president in charge of the incandescent lamp department.

L. S. Hamaker Promoted by Republic Steel Corporation

L. S. Hamaker, sales promotion manager of the Republic Steel Corporation, Youngstown, Ohio, has been advanced to the position of vice-president and general manager of The Berger Manufacturing Company, Canton, Ohio, wholly owned subsidiary of Republic, it is announced by B. F. Fairless, first vice-president of Republic. The appointment was effective June 1.

Mr. Hamaker began his career in the steel industry in the sales department of The Berger Manufacturing Company and later was made advertising manager. During a series of mergers he became advertising manager of United Alloy Steel Company, Central Alloy Steel Corporation, and finally of Republic Steel Corporation, when that organization was formed. He was appointed sales promotion manager of Republic in 1931.

E. E. Spargo to Pittsburgh Equitable Meter Company

The Pittsburgh Equitable Meter Company, Pittsburgh, Pa., announces the addition of E. E. Spargo to its sales force. Mr. Spargo, who will specialize in liquid meter sales, has a background of many years' experience in the equipment business. Following two years with the Fry Equipment Corporation, he joined the Wayne Pump Corporation in 1928. Three years later he went with the Pennsylvania Pump Company, where he was successively sales manager of the Philadelphia and Pittsburgh offices. He was serving in the latter capacity when he joined the Pittsburgh Equitable Meter Company.

Mr. Spargo will be located at the New York office and will cover the eastern territory.

Republic Steel Appoints Distributors

Appointment of Railey & Milam, Inc., 27-39 West Flagler Street, Miami, Florida, as distributors of Enduro Stainless Steel and Toncan Iron, has been announced by N. J. Clarke, vice-president in charge of sales, Republic Steel Corporation, Youngstown, Ohio. Mr. Clarke also has announced the appointment of the Ohio Valley Hardware & Roofing Company, Evansville, Indiana, as distributors of Toncan Iron.

American Iron and Machine Works Opens Houston Plant

G. S. HINKLE

P. K. RIDGE

American Iron and Machine Works Company has opened a new plant at 2205 Quitman Street, Houston, Texas.

H. M. (Mike) Myracle, manager of the Houston plant, announces that P. K. Ridge will represent the company in Southwest Texas and George S. Hinkle in Southeast Texas and Louisiana.

Mr. Myracle states: "Our business in the Gulf Coast area has grown to such an extent that we have not only put in a manufacturing plant, but are maintaining a warehouse stock and a complete shop for all kinds of oil field repairing."

Officers of American Iron and Machine Works Company are well known in the Gulf Coast fields, having spent many years in that area and in the Louisiana fields.

Ralph P. Brown Joins Advertising Department of Timken

Ralph P. Brown, formerly in charge of publicity for the National Lime Association and the Brown Instrument Company, and more recently conducting an independent business paper editorial service in Cleveland, Ohio, has joined the advertising department of the Timken Roller Bearing Company and the Timken Steel and Tube Company, Canton, Ohio.

Mr. Brown is a graduate engineer and has had a wide experience in writing for the industrial press. It will be his duty to co-operate with the business and technical press editors in the preparation of articles dealing with alloy steels and bearings.

Van Bennett Honored

Van Bennett, engineer for the Derby Oil Company in the McPherson, Kansas, district, has been appointed vice-chairman of the Kansas Chapter of the American Petroleum Institute. The announcement was made by Chairman Tom Hamilton, superintendent for the Phillips Petroleum Company in the McPherson area. Lloyd Pickrell, of the Tom Johnson organization, has been named chairman of the membership committee.

Opens Factory Branch

The Chapman Valve Manufacturing Company, Indian Orchard, Mass., has re-opened a direct factory branch in Tulsa, Oklahoma, at 111 West First street. E. H. Gaddis is in charge.

Universal Moves New York Office

Universal Oil Products Company, owner of the Dubbs cracking process, has moved its New York office to 50 West Fiftieth Street.

COOL AS A DRAUGHT
from a mountain spring
Gotkool
WATER CANS
& COOLERS
With the GOTT Water Cooler handy, you will always be assured of a fresh supply of pure drinking water kept delightfully cool — it's health insurance...Order one from your supply store today!
Gott
H. P. GOTT MFG. CO., Winfield, Kansas
KEEP PURE DRINKING WATER ALWAYS HANDY

THE *Standard* WATER CAN OF THE PETROLEUM INDUSTRY

Unusual durability
Metal-to-metal principle
Outstanding performance
Available in all standard bores in both tubing and rod types.

AXELSON
Manufacturing Company
P. O. Box 710, Vernon Station, Los Angeles, Cal'f.
50 Church Street, New York City
Tulsa St. Louis
Mid-Continent & Eastern Distributors:
Frick-Reid Supply Corporation
Rocky Mountain Distributor:
Great Northern Tool & Supply Co.

AXELSON SUPER SERVICE PUMPS

SPERRY-SUN WELL SURVEYING CO.
1608 WALNUT STREET, PHILADELPHIA, PA.
DALLAS, TYLER AND HOUSTON, TEXAS. TULSA, OKLAHOMA AND LOS ANGELES, CALIFORNIA
SURWEL (Gyroscopic) • **SYFO** (Ink Bottle)
UNDERGROUND WELL SURVEYING SERVICE

Renew Your Subscription..Now

keeps us young . . .

A DOZEN years ago, refinery pressures and specific gravities were lower . . . and liquid level controllers designed for water service were satisfactory. Processes began to advance and Mason-Neilan saw the need for improved level control and developed a frictionless ball-bearing controller solely for oil service.

When liquids grew even lighter and corrosive conditions more severe, Mason-Neilan was ready with a highly sensitive pilot-operated type . . . with controllers having all internal parts made of 18-8 stainless steel at regular prices . . . with instrument type level controllers for specific interface applications.

Mason-Neilan now manufactures nine distinct types of liquid level controllers, each one best suited to some particular gasoline plant or refinery requirement . . . developed *in and for* the Oil Industry by oil-trained engineers. Your nearest Mason-Neilan engineer will be glad to help you obtain exact control of liquid level, pressure, temperature and rate-of-flow by recommending the correct type of Mason-Neilan Control Equipment for every service.

MASON-NEILAN

REGULATOR COMPANY

Consolidation of Mason Regulator Co. of Boston and Neilan Co., Ltd., of Los Angeles

1190 Adams Street, Boston, Mass.

BALTIMORE, Whitaker Building . . . . Morton Mc I. Dukehart & Co.
CHICAGO, 435 North Michigan Avenue . . Gordon Thomason, Manager
HOUSTON, 1400 Conti Street . . . . Maintenance Engineering Corp.
LOS ANGELES, 2446 Enterprise St. . . . . Tunnell & Co.
MONTREAL, Canada, 620 Catheart St. W. . . . Maurice Peiler, Manager
NEW YORK, 19 Rector Street . . . . . Rudolph B. Werey, Manager
PHILADELPHIA, 930 North Front Street . . . Baeuerle & Morris, Inc.
PITTSBURGH, Clark Building . . . . . Bruce Irwin, Manager
ST. LOUIS, 2726 Locust Boulevard . . . . O'Brien Equipment Company
SYRACUSE, N. Y., 640 Gurney Building . O'Brien Steam Specialty Company
TULSA, 409 East Archer Street . . . . . Moorelane Company

YOU CAN BE SURE OF MASON-NEILAN PRODUCTS

INDEX *to* ADVERTISERS

A
Allis Chalmers Mfg. Co.
American Cable Co. 56
American Hammered Piston Ring Co.
American Lubricator Co.
American Meter Co. 73
American Sheet & Tin Plate Co.
American Steel & Wire Co. 82
Armstrong Bros. Tool Co.
Axelson Manufacturing Co., Ltd. 79, 74 and 83

B
Baker Oil Tools, Inc.
Baroid Sales Co.
Biltmore Hotel
Bradford Motor Works 82
Bridgeport Machine Company, The 79
Broderick & Bascom Rope Co.

C
Chaplin-Fulton Mfg. Co., The
Chapman Valve Manufacturing Co., The 77
Clark Bros. Co. 1
Continental Supply Co., The
Cooper-Bessemer Corporation, The 67, 31

D
Dresser, S. R. Mfg. Co.

E
Eagle-Picher Lead Company, The
Elliott Core Drilling Co.
Emsco Derrick & Equipment Co. 2
Ethyl Gasoline Corporation 67

F
First National Bank in Dallas 7
Frick Reid Supply Corp. 6

G
Gaso Pump & Burner Mfg. Co.
General Electric Co. 45
Gott, H. P., Mfg. Co. 81
Guiberson Corporation 19
Gulf States Utilities Co. 58

H
Hazard Wire Rope Co.
Houston Lighting & Power Co. 60
Hughes Tool Co. Front Cover
Hydrauger Corp., Ltd. 77

I
International Derrick & Equipment Co.
International Harvester Company of America 4

J
Jones & Laughlin Steel Corporation
Jones, S. M., Co., The

K
Kansas Gas & Electric Co. 59
Kobe, Inc. 75

L
Landis Machine Co., Inc.
Lane-Wells Co.
Leschen, A., & Sons Rope Co. 10
Linde Air Products Co. 17
Lufkin Foundry & Machine Company 42
Lufkin Rule Co. 77

M
Magnolia Petroleum Co.
Martin-Decker Development Co., Ltd.
Mason-Neilan Regulator Co. 84
Mepham, Geo. S., & Co.
Metric Metal Works
Merco-Nordstrom Valve Co.
Moore, Lee C., & Co.

N
National Supply Companies, The 13
National Tube Co. 3
National Tube Co. (Stainless)

O
Oil Well Supply Co. 5
Oklahoma Gas & Electric Co. 41
Oxweld Acetylene Company 17

P
Patterson-Ballagh Corp.
Petroleum Rectifying Co. Inside Back Cover
Pittsburgh Equitable Meter Co.
Prest-O-Lite Company, Inc., The 17

R
Reda Pump Co. 51
Reed Roller Bit Company
Republic Steel Corporation 33-34

S
South Chester Tube Co.
Southwestern Gas & Electric Co. 47
Sperry-Sun Well Surveying Co. 83

T
Texas Electric Service Co. 55
Texas Power & Light Co. 48
Thermoid Rubber Co. 8
Tretolite Company Inside Front Cover
Trimont Mfg. Co.
Twin Disc Clutch Co.

U
Union Carbide & Carbon Corp. 17
Union Carbide Sales Company 17
United States Rubber Co.
Union Wire Rope Corp. Back Cover

W
Waukesha Motor Co.
Wickwire Spencer Steel Company 71

Y
Youngstown Sheet & Tube Co. 68